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ABSTRACT

This report, produced by acknowledged experts in scientific research and in science administration from both the minority and majority community, proposes mechanisms for the development of nationally competitive research efforts at historically black colleges and universities (HBCUs) and for establishing parity for blacks in science and technology careers. Following an executive summary, four separate papers are presented. These papers address issues related to and discuss plans for: (1) strengthening and expanding doctoral study and research programs in HBCUs; (2) strengthening and expanding undergraduate programs in HBCUs; (3) significantly increasing the number of high school students selecting careers in science and technology; and (4) expanding and establishing collaborative research programs between universities, industry, and national laboratories. Each includes a summary, introduction, programmatic thrust (goals), mechanisms for implementation, recommendations, and other information unique to the specific component addressed. Efforts in these areas are designed to increase the pool of minority scientists; improve the quality of faculty at all levels; improve facilities; and provide strategies to secure, as well as sustain, funding for these programs. (JN)

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PREFACE

Executive Order #12320 was issued with this directive to strengthen the research opportunities and programs at HBCUs. The Arrowhead Conference: "Long-Term Activities for Minority Institutions in Science and Technology", is a response to this Executive Order. It is our firm belief that in order to give substance to such an order, there must be a long-term program developed which will appropriately direct the efforts of HBCUs, industry, and federal agencies.

This report, produced by acknowledged experts in scientific research and in science administration from both the minority and majority community, proposes mechanisms for the development of nationally competitive research efforts at HBCUs, and for establishing parity for Blacks in science and technology careers.

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EXECUTIVE SUMMARY

The underrepresentation of minorities in science is a grave problem, destined to become critical if definitive and effective measures are not immediately taken. The effects of this underrepresentation with respect to the Nation and the minority community are difficult to measure quantitatively. However, it is certain that the Nation is denied the talents of millions of American minds, and they are in turn denied the opportunity to participate in the new technologies that are reshaping our lives and the world. The social impact of technology is more evident now than ever. The decisions to be made in the environmental sciences, in biochemistry, and in computer technology have as much impelling social effect as scientific significance. The problems of chemical and radioactive waste disposal and their effects on the environment, the exciting as well as frightening possibilities for gene manipulation, and the management of massive amounts of information, as provided by new advances in computer technology, will all impact the minority community. The decisions made in these areas will, in many cases, directly involve the minority community and as such, the minority community must participate in both the solutions of these problems, as well as the final decisions.

The widening "high-tech gap" between the majority community and the minority community has the potential of seriously diminishing the accomplishments of the Civil Rights Movements of sixties. We are faced with the possibility of the creation of a second-class citizenery, who instead of being denied the right to vote, will be denied the opportunity to participate in, to make decisions about, and to profit from the advancements in science and technology. With little imagination, one can envision the already disastrous unemployment rates of Blacks and other minorities increasing as more and more technical jobs replace non-technical jobs. As Dr. Martin Luther King stated, "The final solutions to civil inequality is to be found in education and economics."

The statistics of Table 1 clearly illustrate the severity of the problem. Blacks make up only 4.1 percent of all B.A. degrees, 2.5 percent of all M.A. degrees, and 1.7 percent of all Ph.D. degrees in the physical sciences, mathematics, computer sciences, biological sciences, engineering sciences, and economics. Except for Asian Americans, the remaining minorities fare even worse. In contrast, Blacks are overrepresented in certain non-science disciplines. For example, while in 1979/1980, only 2 percent of the Ph.D. degrees awarded Blacks were in the quantatively based disciplines, 55 percent of all Ph.D.s awarded to Blacks were in education. These statistics should be compared to the 29 percent quantatively based degrees, and 25 percent education degrees awarded to whites.

The statistics show a clear inequality in the minority representation in science and technology; however, as is usually the case with statistics, they do not clearly show the reasons for this inequality or readily point to the solutions of the problem.

There have been many attempts by individual scientists, educators, institutions, federal agencies and private industries to increase the minority participation in science and technology. However, as indicated in Table 1 below, minorities are still greatly underrepresented in science and technology. These past efforts, however, have had substantial impact on minority involvement in science and in fact, have laid the foundation for our efforts in this report.

TABLE 1. 1980 U.S. Population, Science/Engineering Workforce, and Doctoral Scientists and Engineers by Race Ethnicity

RACE/ETHNICITY	% IN POPULATION	% IN S/E WORKFORCE	% IN DOCTORAL S/E
White	79.6	95.0	89.0
Black	11.5	1.9	1.1
American Indians	0.6	a	b
Asian/Pac Isl	1.5	2.8	6.6
Spanish Origin	6.4	a	b
Other/No Response	0.4	a	b
	100.0	100.0	100.0

NOTE: Categories with "a" total 0.3% of the 1980 Sci/Eng workforce categories with "b" totaling 3.3% of the Doctoral Sci/Eng.

SOURCE:
National Science Foundation, U.S. Scientist and Engineers, 1980, NSF 82-314.

Specifically, the ultimate goal may be stated as:

> **The establishment of a nationally competitive effort by selected minority institutions that will make a significant contribution to maintaining the preeminence of the Nation in science and technology.**

In order to realize this objective, it is necessary to:

1. Provide a mechanism for increasing the quality of graduate research programs at minority institutions;
2. strengthen the quality undergraduate academic programs at minority institutions;
3. provide a mechanism for increasing the involvement of science and technology; and
4. provide a mechanism for interfacing industry and national/federal laboratories with minority institutions.

It is recognized that each phase of the educational process (pre-college education, undergraduate education, and graduate education) are intimately interdependent, and a synergistic approach is expected to have the most significant impact.

To this point, we have divided this effort into four (4) components -- pre-college programs, undergraduate programs, graduate programs and cooperative programs. It is hoped that this effort will provide a totally integrated approach: (1) increase the pool of minority scientists, (2) improve the quality of faculty at all levels, (3) improve facilities, (4) expand resources, and (5) provide strategies to secure, as well as sustain funding for these programs.

In order to meet the above objectives and achieve the ultimate goal stated above, minority institutions must be innnovative and forward thinking. They must concentrate their efforts on those issues which will be of technical and social importance in the long-term development of the Nation and the world. These issues include: population (health, nutrition, food supply); resource development (energy and materials); productivity (e.g., biotechnology, computer technology); and the environment (e.g., air and water quality, and waste management). These issues and areas should constitute the primary focus of our scientific efforts.

This is a monumental task -- particularly when considering an assessment of our present state. Minority institutions are entrenched in certain fundamental pitfalls which preclude rapid scientific development. These "pitfalls" are the following:

1) There is a need for more effective science administration and infrastructure in educational institutions, e.g., elementary, high school, and college
2) Most of the minority community (<98%) is unaware of the benefits and application of science and technology.
3) Minority students are continually counseled away from science.
4) There is a consequential apathy and lack of understanding of the importance of science and technology by minority youth.
5) Approximately 98% of all minority undergraduate chemistry, physics, and mathematics departments provide support service from the pre-medical, engineering, and non-science programs, as opposed to approaching their educational duties with the objective of training students for Ph.D. programs in science.

These points underscore the need for educational programs for the community and school administrators, as well as for students.

There is also a distinct absence of science for science sake, and the lack of a "research environment" at most Black institutions. For example, there are presently no minority-run research institutes, material laboratories, or industrial research centers, such as the California Institute of Technology-Jet Propulsion Laboratory, the University of California-Lawrence Berkeley Laboratory, and the University of Chicago-Brookhaven National Laboratories. At least, a very few minority institutions are in the initial developmental stages of establishing research organizations with the purpose of becoming involved in first-class research of national importance (e.g., the Science Research Institute at the Atlanta University Center).

We present here a comprehensive program for addressing these problems and achieving the stated objectives.

The goal of the pre-college group is to provide mechanisms for increasing the pool of capable, well-trained minority students in science. The undergraduate group proposes criteria for the development of strong and competitive undergraduate programs. The goals of the graduate group are to provide mechanisms for increasing the competitive research capabilities at minority institutions and increasing the number of minority Ph.D.'s in science. The cooperative group is concerned with University-University (U-U), University-National Laboratory (U-NL), and University-Industry (U-I) cooperative programs. These different types of interaction provide a mechanism for increasing the rate and depth of research development at minority institutions.

We emphasize the importance of a long-term commitment to our efforts from federal and private funding sources. Provided that the recommendations given in the presentations are followed, it will take no less than fifteen years for realization of these stated goals by selected minority institutions.

The remainder of this summary summarizes the recommendations of the four component groups. While related synergistically, each of the four components can be implemented independently.

GRADUATE PROGRAM COMPONENT

Doctoral study programs and research activities at Historically Black Colleges and Universities (HBCUs) have remained relatively small. Nevertheless, they have contributed a large proportion of the Nation's Ph.D. trained scientists and engineers. Clearly these institutions have great potential for added contribution to human resource development in the training of doctoral students and in the advancement of knowledge through stronger, expanded, and more competitive research programs. This report describes a plan to achieve these important improvements.

The specific goals are as follows:

1. Develop stronger competitive research programs.
2. Significantly increase the number of doctoral trained Black scientists and engineers.
3. Establish state-of-the-art national research facilities at HBCUs.
4. Increase the role of Black scientists and engineers in entrepreneurship for improved productivity, economic development, and improved international competitiveness.
5. Increase university-industrial interaction to support improved doctoral study and research at HBCUs.

To focus resources more rapidly in achieving these goals, the following actions are recommended:

1. More and expanded programs should be funded at selected institutions from currently available authorizations and financial resources, as described in the full report.
2. Each program area of every federal funding agency should provide significant support for these programs.
3. Although initial awards would be for five years, it will be necessary for each program to receive continued base support for a period of at least fifteen (15) years.
4. Industry should participate in the support of HBCUs in a collaborative effort toward achieving the goals listed above.

5. An external review committee should be established to monitor the impact of each program on:

   A. Doctoral program quality and productivity

   B. Faculty recruitment and development

   C. Administrative structure

   D. Institutional program support

   E. Physical facilities

   F. Cooperative interaction with

      a. other educational institutions

      b. governmental laboratories

      c. industrial corporations

Funding for each university run program would be provided in two ways and it is recommended that at least four such programs be established nationwide.

1. Implementation grants of at least $500,000 per university site should be provided to support start-up preparation.

2. Each university program should have base funding of $5 million for the first year, increasing to $7.5 million in the fifth year, remaining constant in real dollars for five years, and declining and phasing out at the end of the fifteenth year. As the program is strengthened, it will attract other funding so that steady increases in resources will provide stand-alone competitive funding after fifteen years.

3. Initial funding for special equipment and facilities should be provided for each program.

4. Funds should be provided for research institutes which support and contribute to the university based program which are separately administered.

To build competitive doctoral study and research programs, the basis of evaluation for support would be:

   a. active research faculty with demonstrated productivity

   b. a productive history of contributing to Black students completing doctoral degrees

c. successful competition for research grants

d. a core faculty with significant strength to contribute to this program

e. quality of the graduate research program.

The four specific measures of success would be:

a. research publications

b. graduation of doctoral students

c. award of competitive research grants.

d. development of a successful research infrastructure.

This would be an open-ended program concept where new programs could be added from year-to-year as resources, national needs, and instructional strengths are developed.

UNDERGRADUATE PROGRAM COMPONENT

There is concern about the quality of science instruction and research opportunities available to minority students, particularly those enrolled in predominantly minority colleges and unversities. To address this concern, we present an improvement plan spanning twenty years focusing on the creation of first-rate undergraduate science programs at selected minority institutions.

The objectives of this plan are:

1. To increase the number of minority students capable of successfully completing Ph.D. programs in quantitatively-based science fields
2. To improve the quality of science programs at selected minority institutions by:
    - Increasing the number of faculty in key areas
    - Enhancing research opportunities for faculty and students
    - Creating opportunities for faculty to earn the Ph.D. degree or to improve skills in critical areas (e.g., computer science)

Fifteen (15) minority institutions will be chosen through a competitive process to recruit approximately 50 outstanding minority students at each institution (for a total of 750) to participate in a high quality academic science program. The program will include a pre-freshman summer, special retention program efforts (especially during the freshman year), undergraduate research opportunities, and guaranteed graduate support for two years in key identified science areas (e.g., physical, mathematical, and computer sciences).

It is projected that of the original 750 students, 375 will complete the undergraduate programs in the areas identified, 200 of which will be admitted to Ph.D. programs, and 120 will complete the Ph.D.degree in quantitatively-based science fields. Currently a total of 39 Ph.D.'s per year are produced in these areas.

To prepare a high quality and competitive science graduate, it is necessary that enhancement of faculty and curriculum occur in key areas through grant awards. Institutions eligible to compete for awards should meet the following criteria:

1. Offer the B.S. degree in at least four of the following areas: biology, chemistry, physics, mathematics, and computer science.
2. At least 50% of the faculty in the areas above should have the Ph.D. degree.
3. At least 30% should be actively engaged in research and publishing in refereed journals.

It is expected that the institutions chosen will meet the following criteria at the end of ten years:

1. Offer a degree in computer science.
2. Seventy-five percent (75%) of the faculty will have the Ph.D. degree
3. Sixty percent (60%) of the faculty will be actively engaged in research and publishing in referred journals.

All proposals will include support for external evaluation, with visitation occurring every two years.

Recommendations

Funds should be provided to sufficiently carry ten succeeding student groups through the program and to effect the changes proposed in the undergraduate programs at the selected institutions as follows:

1. INCREASE FLOW INTO SCIENCE AND TECHNOLOGY $140 Million

   750 Freshmen $\xrightarrow{\text{9-Year Cycle*}}$ 120 quantitatively-based Ph.D.s/Year**

2. ENHANCE UNDERGRADUATE PROGRAM QUALITY $ 35 Million

   (Addition of computer science major at 15 institutions; increase the number of faculty engaged in research from 30% to 60%; increase the number of faculty with Ph.D. degrees from 50% to 75%; increase the size of the science faculty by 20%; and support an external evaluation team)

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* Estimated cost of single 9-Year Cycle beginning in 1985 is $10 million.

**Does not include those who will opt for other science-based fields at various decision points in the cycle.

PRE-COLLEGE PROGRAM COMPONENT

In order to continue to produce sufficient numbers of scientists and engineers to meet the Nation's needs, we must initiate steps to ensure that the pool of capable science-oriented high school graduates remains high.

While there is an urgent need to increase the understanding of scientific and technological issues, science and engineering education activities are at their lowest ebb since the early 1970's. Several studies point out serious deficiencies:

1. Decreasing priority is being given to science and mathematics in the secondary schools in marked contrast to Germany, Japan, and the Soviet Union. For example, at least half of the Nation's youth graduate from high school with no mathematics beyond algebra.

2. There is an immediate problem in acquisition, retention, and maintenance of high quality faculty to teach science courses at the pre-college level.

As serious as the problem is generally, the effect on minority students is even more severe:

> Too few minority students graduate from the nation's high schools with sufficient academic preparation in mathematics, science, and communication skills to pursue courses of study in our colleges and universities that lead to careers in science, mathematics, and technology.

The following factors contribute to this problem.

1. Institutional Factors
    - Little emphasis on skills development
    - Poor counseling
    - Exclusion based on race/background expectation
    - Inadequate facilities for science instruction
    - Lack of common goals
2. Teacher Factors
    - Insufficient teaching preparation in mathematics and science, K through 12
    - Lack of teaching expectation
    - Lack of teaching motivation
    - Lack of skills/interest in teaching minority students
3. Student Factors
    - Poor attendance
    - Low interest in science and mathematics
    - Poor self-concept

The urgency of the problem requires both immediate and long-term solutions and dictates programmatic thrusts in the areas of institutional development, teacher improvement, and student focused programs.

In order to significantly increase the pool of minority students with the interest and academic preparation to pursue technical careers, a high priority must be given to elementary and middle school education, as well as preadolescent informal educational activities. Programs at the secondary level should continue the support for efforts started at the earlier levels as well as address the needs of students omitted from earlier efforts.

The following programmatic recommendations are proposed as solutions to the above problems. We present a structure to link public schools, the community, universities, and industry in a focused coordinated effort to provide student motivation and opportunity.

The projected cost of these recommendations is approximately 12 million dollars per year over an initial five year period, and 8.5 million dollars per year over a subsequent ten year period.

Recommendations

	5-YEAR COST IN MILLIONS
HBCUs NATIONAL EDUCATION RESEARCH CENTERS	
1. Development and Demonstration Center for Minority Education	7.0
Sample Projects	
. Local School Improvement and Implementation Projects	10.5
. Teacher Renewal Projects	12.0
. Research and Development in Math/Science Education	6.0
2. HBCU Centers of Excellence for Pre-College Science/Math Education	3.0

Sample Projects:

- Informal/Out-Of-School Projects
- Counselor Programs
- Teacher Center
- Resources Development

3. Faculty and Program Development Projects for HBCUs 12.5

- Undergraduate Science Education Program Enrichment
- Staff Development
- Equipment/Faculty Acquisition

4. Schools and Programs for Able Students 5.0

Sample Projects:

- Magnet/Special Schools
- Comprehensive Science Achievement Program

5. Public and Informal Education Programs 3.4

Sample Projects:

- Exhibits
- Networks
- Bulletins
- Museums/Science Tech Centers

COST OF TOTAL PRECOLLEGE INITIATIVE:

5-YEAR TOTAL: $60 MILLION

PER YEAR COST: $12 MILLION

COOPERATIVE PROGRAM COMPONENT

Minority universities in collaboration with other academic institutions, industries, and national/federal laboratories represent an effective vehicle for developing the universities' scientific and engineering programs and enhancing research development. For this reason, cooperative programs deserve special attention. These programs provide an effective means of technology transfer to the university, with little initial investment by the university. This concept can be used as support to the implementation of the graduate or undergraduate components, or stand alone. Cooperative programs are especially attractive since they can positively affect colleges and universities in all stages of development. For several reasons, it does not appear to be presently economically feasible or practical for many minority universities and colleges to independently develop curricula and research programs in certain high-tech areas. First, these institutions would have to compete for faculty and students with institutions that have established programs. Second, to establish a reputable program, a number of new personnel would be required. These resources are few in number, and the strain on the budgets of most minority institutions would be great. Third, specialized equipment is required which is beyond the financial capability of most minority universities and colleges.

Clearly, integrating high-tech research programs into the curricula of minority institutions would be difficult at best, if attempted independently. Yet, the projected demand for personnel in new science and technology areas is great, and there is a distinct need for these institutions (who educate a significant portion of the nation's students) to participate in this education. A final incentive for the development of cooperative high-tech programs at minority institutions is the prospect that they would be entering these fields with developed partners, and would not be facing the prospect of playing "catch-up" in existing, extensively developed fields.

The principal motivators for a minority university to develop a cooperative program are:

1. to increase scientific facilities and capability;
2. to improve human resource development;
3. to increase involvement in the planning and execution of science on a broad base;
4. to accelerate the development of existing research programs through peer interaction and scientific exchange with other scientists;
5. access to special facilities; and
6. assistance in building and sharing technical support services.

Also, an important opportunity exists for minority universities to expand their relationship with industry beyond general research support in the form of industrial philanthropy. Significant opportunities are identifiable for minority institutions in the engineering-computer science disciplines and in establishing relationships with high technology businesses. This type of connection could lead to the development of industrially affiliated programs at HBCUs where several companies support the development of a specific scientific sub-discipline (e.g., robotics, artificial intelligence, thermal sciences, microelectronics).

Such linkages provide cost effective methods for achieving the stated objectives. Several prototypes and models already exist and are discussed in the text of this document.

The estimated cost of such cooperative programs depends on the type of cooperation (U-U, U-I, U-NL), and the level of technical development at the university. Thus, cost projections are variable and difficult. Rather, it should be recommended that a primary result of any cooperative effort must result in a strengthening of the HBCUs capability to perform in-house research. Several conditions must then be met. There must be sufficient funds to support university faculty participation. There must be educational activities such as short courses and seminars directed at increasing the university community's awareness and knowledge of the chosen research programs. There must be sufficient funds for travel and visiting faculty. Finally, there must be funds for equipment and facilities to be installed at the university, since the university must make a significant contribution to the research product. The average cost for such a program, estimated from the actual cost of the programs described in this report, is approximately $300,000 to $500,000 per three year period.

Recommendations

It is recommended that several programs of Federal agencies support the establishment of the following cooperative interactions:

1) University-University
2) University-National Laboratory

Further it is recommended that industry select several universities with which to develop strong cooperative efforts, resulting in mutual research benefits.

THE GRADUATE PROGRAM COMPONENT

Plan To Strengthen and Expand Doctoral Study and Research Programs
in
Historically Black Colleges and Universities

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SUMMARY

Doctoral study programs and research activities at Historically Black Colleges and Universities (HBCUs) have remained relatively small. Nevertheless, these programs have contributed a large proportion of the nation's Ph.D. trained scientists and engineers. Clearly, these institutions have great potential for added contribution to human resource development in the training of doctoral students and in the advancement of knowledge through stronger, expanded, and more competitive research programs. This report describes a plan to achieve these important objectives.

The specific goals are the following:

1. Develop stronger competitive research programs.
2. Significantly increase the number of doctoral trained Black scientists and engineers.
3. Establish state-of-the-art national research facilities at HBCUs.
4. Increase the role of Black scientists and engineers in entrepreneurship for improved productivity, economic development, and improved international competitiveness.
5. Increase university-industrial interaction to support improved doctoral study and research at HBCUs.

To focus resources and move more rapidly in achieving these goals, the following actions are recommended:

1. More and expanded programs should be funded from currently available authorizations and financial resources.

2. Each program area of every federal funding agency should provide significant support for these doctoral and research programs.

3. Although initial awards are recommended for five years, it is necessary for each program to receive continued base support for a period of at least fifteen years.

4. Industry should participate in the support of HBCUs in a collaborative effort toward the goals listed above.

5. An external review committee should be established to monitor the impact of each program on

    A. Doctoral and research programs

    B. Faculty recruitment and development

    C. Administrative infrastructure

    D. Institutional support of the program

    E. Physical facilities

    F. Cooperative interaction with

        a. other educational institutions

        b. governmental laboratories

        c. industrial cooperations

Funding for each university run program would be provided in four ways, and it is recommended that four such programs be established nationwide.

1. Implementation grants of at least $500,000 per university site should be provided to support start-up expenses.

2. Each university program should have base funding of $5 million for the first year, increasing to $7.5 million in the fifth year, remaining constant in real dollars for five years, and declining and phasing out at the end of the fifteenth year. As the program is strengthened, it should attract other funding so that steady increases in resources will provide stand-alone competitive funding after fifteen years.

3. Initial funding for special equipment and facilities should be provided for each program.

4. Funds should be provided for research institutes which support and contribute to the university based program but which are separately administered.

To build competitive doctoral study and research programs, the recommended criteria for evaluation of support are the following:

a. active research faculty with demonstrated productivity

b. a productive history of Black students completing doctoral degrees

c. successful competition for research grants

d. a core faculty with significant strengths to contribute to this program

e. quality of the graduate research program.

The three specific measures of success would be:

a. research publications

b. graduation of doctoral students

c. award of competitive research grants

d. development of a successful research infrastructure

This would be an open-ended program concept where new programs could be added from year-to-year as resources, national needs, and instructional strengths develop.

INTRODUCTION

This position paper addresses an effective long-term response to the need for graduate education in science and technology at minority institutions which produce more and better trained Ph.D. students who have strong research experiences. Such a response is required so that the intellect of larger numbers of minorities can be directed towards solving scientific and technological problems of national importance. In the past, research and development federal dollars have been awarded predominantly to one hundred universities in areas of research that deal with populations, natural resources, the environment, and biotechnology. Unfortunately, no minority institution was included within that one hundred. It is essential that graduate education in minority institutions participate in a meaningful way in the above research areas if the goal of producing more and better trained minority Ph.D.'s is to be realized. In this position paper, mechanisms will be defined through which minority institutions with both commitment towards the scientific and technological potential for excellence in graduate education can be identified and subsequently effectively supported.

The standards used to delineate those graduate institutions or consortia with a demonstrated acquisition of essential prerequisites of excellence are precisely defined. The precision of definition is deliberate and aimed towards assuring that the program design leading to excellence in graduate education will not be diluted by the undesirable inclusion of institutions that cannot achieve the excellent status within a finite period of fifteen years.

To achieve the ultimate goal of this conference, the establishment of a nationally competitive effort that makes a significant contribution to maintaining the preeminence of the nation in science and technology, we have made difficult, but necessary decisions regarding the nature of the minority institutions that will participate in this particular concerted effort. Doctoral granting institutions must be considered in terms of their institutional commitment - real and tangible; their administrative infrastructure - either already in place or in development; and the quality of academic and research programs as reflected by the products of the programs. For our purposes, the quality of the Ph.D.s produced is used as a significant measure of the quality of the combined academic and research efforts, while the number of peer reviewed publications and presentations in nationally recognized journals of merit signal a measure of the quality of the research performed. In addition, the diversity of doctoral programs offered will be considered. This consideration must be made because of the difference in developmental potential within the time frame specified between institutions with one versus several doctoral disciplines already initiated.

Master's level programs that provide research-based experience directed towards Ph.D. programs must be supported. Such master's programs are distinct from those that provide the M.S. degree as a termination rather than an entree into a Ph.D. program. Monitoring is facilitated by observing whether graduates of the master's program of a particular institution move into Ph.D. programs.

The criteria and recommendations outlined in this position paper are given so that funding agencies may focus their resources for graduate education upon those institutions which are capable of and committed to the criteria of research infrastructure development which fosters the implementation and competitive research programs. For all minority institutions, this position paper sets forth models, research infrastructures, standards for evaluation, and cost analysis procedures needed to effectively launch competitive graduate research activities. It is understood that in certain instances, consortial arrangements, the establishment of research institutes, or centers may be needed for a given institution or group of institutions to meet the standards given. Such arrangements or need for these arrangements, however, must be identified by the relevant institutions themselves.

BARRIERS TO THE DEVELOPMENT OF COMPETITIVE RESEARCH PROGRAMS

Many universities have the professed desire to develop competitive research programs that attract sizeable amounts of external funds and prestige to their institution. In all of these institutions, there are both internal and external barriers that prevent them from achieving these goals. Here, we will describe the barriers and illustrate how these barriers impact on HBCUs.

External barriers to the institutional pursuit of competitive research programs revolve around the perception of the community about the intellectual capability of a given institution. If the external community believes that a particular institution is outstanding, they will then play a significant role in confirming that belief. By the same token, if the external community believes that an institution is inferior, they can hasten its decline into inferiority. Proposals that are submitted by institutions in the latter category are more critically scrutinized than those in the former. Better faculty, students, and staff are more easily recruited to those places that have a "reputation" than to those without one. External funds from private donors also follow the same pattern. It is therefore important for the world at large to have a true measure of the quality of a particular institution.

Even when a particular institution develops an outstanding project, it is often disparged by unsupported comments or evaluations which generally discourage successful funding of the grant or contract application.

These negative attributes accorded to a so-called inferior institution are magnified ten-fold when applied to Black institutions. These external perceptions have a sociological bias that is consciously and unconsciously built into our society. Many well meaning people, both Black and white, have not been exposed to outstanding Blacks and, hence, conclude that very few exist. Society, in general, has systematically denied that Blacks have in the past, and can in the future develop outstanding programs. Thus, it is extremely important that any programs instituted at HBCUs be significant so that the larger community will rethink its previous conceptions of that institution. The new thrust must be sufficiently significant that it can be sold to the larger community as representing a recognition of the excellence that is being developed. There may be those who state that the reputation can also be further tarnished if the program fails; however, without high aspirations, high goals cannot be achieved.

In addition to the external barriers about the perception of the institution, there are internal barriers that also must be overcome. Some of these are also perceptual; others are organizational. Starting with the perceptual, no HBCU was organized with the fundamental idea of furthering the state of knowledge of mankind. Rather, they were defined as institutions where Black people could begin receiving advanced education. Thus, they were established as "teaching" institutions rather than "research" institutions. To become one of the latter, they must perceive themselves as research institutions. This will naturally result in conflict between those who desire to maintain the status quo and those who desire to change it. If this natural conflict is recognized, it can be dealt with. To begin with, all research universities must have a strong teaching component. Very few research institutions exist where 100% of the faculty are involved in research. All faculty are necessarily active participants in the process of making the university a viable place for research and learning; where learning is used to describe a process in which both students and teachers participate.

In addition to the internal and external barriers associated with the perception about the quality of the institution, there are also organizational problems that have developed at teaching institutions which are not appropriate for a research institution. Effective research institutions have, not only outstanding faculty and students but, responsive administrators. These responsive administrators take it as their goal to make sure that the faculty and students have the resources to pursue new knowledge. What does this mean? It means that programs are developed to insure that procedures relating to research can be accomplished more easily and in a timely fashion. It also means that they view their role as being an expediter of research rather than a hindrance. The researchers in turn must be willing to assume ultimate responsibility for the success or failure of their research programs.

To summarize, there are problem areas that any institution will face in changing its orientation. These include changing the internal and external perceptions of their worth. They must recognize that there must be a restructuring of their organizational procedures so that they are responsive to the needs of the researcher. The researcher must recognize that in addition to receiving the rewards for their research, they must accept the responsibility for being the principal agent for the conduct of the research. Finally, they must recognize that they are part of the university, and as such they must respect the legitimate accomplishments of all of their colleagues, even those who may not be outstanding researchers. These qualities will minimize conflicts that normally ensue while institutions are undergoing change.

INFRASTRUCTURE TO SUPPORT THE DEVELOPMENT OF DOCTORAL STUDY AND RESEARCH PROGRAMS

Introduction

Of the more than 3,000 institutions of higher education in the United States, about 120 or 4% handle more than 90% of all organized university research. Conventional institutional organizational systems have no research component. With a small research activity and little or no supporting infrastructure, the burden of providing "everything" that is needed can suppress and discourage even the most ardent research faculty member. This may be one of the reasons why the "big get bigger" and the "small get smaller" in university research. A small but growing university research program has great difficulty upgrading sufficient support functions before the faculty becomes discouraged and ceases to perform research. Thus, any plan to build institutional research programs must build the infrastructure to support research as well. Most research proposals deal with technical excellence and never mention a support system to enable the faculty to perform proposed research.

Characteristics of Infrastructure

Details of research activity support systems must fit the institutional setting and will vary widely. Several functions must be achieved however. Some examples of typical support functions are as follows:

A. Proposal preparation, delivery, contract or grant development and establishment of fiscal and technical information and accountability.

B. Procurement, delivery, installation, and operation of equipment.

C. Effort reporting and accountability

D. Fiscal reporting and accountability

E. Management and administrative support

F. Space and facilities

G. Subcontracting and cooperative agreements

H. Intellectual property rights administration

I. Photographic and reproduction facilities

J. Hazardous waste disposal

K. Instrument calibration

L. Electronic repair

M. Computer Support

N. Travel

O. Animal Care

P. Laboratory Certification

Q. Inventory system

R. Safety Procedures

S. Security

Many of the functions may exist to support an instructional activity but be unsuitable for research. Therefore, a procurement system suitable for bookstore supplies with several months of lead time, may not work well in research programs where a delay of a week may ruin a program.

Leadership

Above and beyond these research functions are the overriding concerns of how research is considered and administered in the institution. Research functions are heavily influenced by policies dealing with tenure, hiring, budget, space, students, sabbatical leave, financial resources, decision processes, and overall attitude and environment. Most faculty will not develop research programs if the department head is not encouraging and supportive. Frequently, research program needs and instructional program needs are in conflict and competition. For research programs, resources must be sharply focused to achieve excellence and recognition (and funding). Instructional programs often dictate broad coverage and wide distribution. The question of "soft" and "hard" money sometimes affects decisions.

In summary, good instructional research leadership is critical in the development of a policy and operational infrastructure that supports improved research programs.

PROGRAMMATIC THRUST

In order for a successful research program to be developed at a minority institution, there must be a significant overlap between the mission of the funding agency and the research interests and strengths of the faculty. Fundamental chemical and physical phenomena of importance to society and most federal agencies include, but are not limited to, the following areas:

(1) Specific Concerns Associated With Population
  (a) health
  (b) nutrition
  (c) food supply
(2) Utilization of Natural Resources
  (a) chemicals from coals, oil shale, etc.
  (b) separation and purification processes
(3) Environmental Concerns
  (a) long-term global habitability, i.e., atmospheric science, space science, chemical climatology
  (b) chemistry of natural waters
  (c) ecosystems
  (d) management of hazardous materials and wastes
  (e) management of wastes

(4) Productivity Technologies

  (a) biotechnology; genetic engineering; biomass

  (b) computer technology/information exchange

(5) International Programs

  (a) culturally related issues in human resource development technology and science

  (b) racially related issues and health nutrition

  (c) energy-productivity-information-environment related to international doctoral training and nutrition

A basic understanding of elementary phenomena is essential in the processes of scale-up and commercialization. By their very nature, such programs may naturally involve research faculty at minority institutions interacting with colleagues at national laboratories, majority universities, and industrial corporations.

In addition to having demonstrated their expertise in various areas of science and engineering, faculty at minority institutions have had more success than their majority counterparts in producing highly qualified minority scientists. Thus, the main non-technical goal of any new program is to enhance current efforts along these lines. Young minority scientists and engineers, capable of competing successfully and contributing significantly to the technical arena, must be trained in a competitive research atmosphere.

There may also be specific areas of opportunity where research faculty at a minority institution may be in a position to make a more significant contribution than anyone else. For example, it may be desirable to develop a medical center of excellence which would focus primarily upon medical and health issues which are of major interest to minorities. Another example might involve interaction with colleges in certain developing countries. It may be possible that research faculty at minority institutions, who have had to develop programs with minimal support, might be better able to assist than faculty at majority institutions.

Further discussion with the granting agencies should be conducted in order to determine specific areas of overlap of interest and technical expertise.

OUTCOMES

The support of graduate research and education programs at HBCUs should result in several outcomes which will impact the funded institutions, sponsors, and society.

Expected outcomes which will impact funded institutions are:

- The conduct of an internal self-study which will assess the strengths and weaknesses of the entities to engage in graduate research and education.
- The development of both long- and short-range master plans for the improvement of graduate research and education in the sciences, biomedical sciences, mathematics, and engineering.
- The production of capable minority Ph.D. recipients and students capable of pursuing Ph.D. degrees in the sciences, biomedical sciences, engineering, and mathematics.
- The production of capable minority M.D. recipients and students capable of pursuing the M.D. degree.
- A strengthened institutional awareness of and commitment for the need to support and sustain graduate research and educational efforts.
- Strengthened science, biomedical science, engineering and mathematics curricula.
- The addition of outstanding research and academic personnel to institutional staffs.
- The upgrading of scientific, biomedical scientific, computational and engineering resources and facilities.
- The development of strong competitive research programs in the biomedical sciences, natural sciences, engineering, and mathematics.

- A strengthened and/or modified institutional research infrastructure. This includes the improvement or addition of support services and personnel. This will allow institutions to achieve a high degree of responsiveness, accountability, and responsibility for conducting research and to become leaders in the scientific, biomedical scientific, engineering and mathematics communities.
- An increase in the number of high quality scientific publications produced by faculty and researchers.
- An increase in research support for various types of projects from other funding sponsors.
- The creation of Centers of Excellence for various focused research thrusts within and among Black colleges and universities.
- The utilization of external review committees of outstanding scientists, biomedical scientists, engineers, and mathematicians to assess and advise institutions of their abilities to conduct research and the effectiveness of their various administrative support systems.
- The establishment of a national Research Facility which will serve as a resource support for Black colleges and universities engaged in research.

Expected Outcomes which will impact sponsors are:

- The expansion of mission and program activities into a segment of the research community which is underutilized or underrepresented in research support afforded by sponsors.
- The exposure of sponsors to groups of researchers with expertise which have not been tapped by industries, national laboratories, and research institutes.
- The creation of a larger pool of researchers who will be able to help address sponsors' missions and problems of interest and items of national priority.

Expected Outcomes which will impact society are:

- An infusion of qualified minority Ph.D. researchers who will, over a period of time, impact managerial and policy aspects of research conducted by universities, national laboratories, industries, and health organizations. The realization of this outcome will help to demonstrate to all segments of society that everyone has an equal opportunity to succeed.

- The expansion of knowledge and expertise when additional persons are educated for scientific, biomedical scientific, engineering and mathematical positions.

- The attention by Black institutions and investigators to problems which disproportionately affect Blacks and their quest for a high quality of life.

- The creation of a larger pool of persons who will be able to address research items of national priority.

GUIDELINES FOR THE IMPLEMENTATION OF THE PROGRAM

In order to implement a competitive research program, top administrators and governing boards of each participating institution must indicate a significant institutional commitment. This commitment may be expressed in a variety of ways; e.g., released time, reduced teaching loads, renovated laboratories, new money, special fund raising campaigns.

It is critical to the success of such a program that the investigators be released from the hinderance of antiquated procedures and processes which would impede the progress of their research and teaching. Therefore, institutions must show that they can expedite the procurement of equipment and supplies needed by the investigators.

The institutions must establish both internal and external review processes to ensure that proper evaluation procedures exist. The agencies and institutions should develop procedures for monitoring the progress and success of projects as a whole and individual in particular. Of prime importance is the development of an adequate infrastructure for the program.

Not only must a comprehensive infrastructure support system be developed, but an ongoing administrative structure must also be developed to operate and extend the support system. Thus, a strong and pervasive research administrative system is required that can be effectively shielded from disruption by other pressing university operational needs and requirements. For doctoral programs, the primary distinguishing characteristic is research. Thus, a pervasive change must occur as doctoral programs develop.

A primary research administrator should be appointed who does not have other primary loyalties such as instruction, finances, development or graduate study. The title may be vice president, vice provost, or similar. Tacking research function responsibility unto other duties is probably unwise, since research may be the smaller and more neglected function.

All research program functions at all levels must report to the research administrator. If he/she is given the responsibility for the development of research, then he/she must have the authority to achieve results. This person must have the responsibility of control and administration of support functions for research as well as control of the research resources and personnel, both sponsored and institutional. Hiring of all faculty, purchase of all equipment, allocation of space, distribution of indirect research income, proposal preparation and negotiation, are all central research program functions that require the review and involvement of research leadership in equal partnerships with instructional, fiscal, and other university functions. The research program leadership is most critical because it is the most dynamic and non-traditional of all functions in a developing institution.

All research infrastructure need not be required full-blown at the start, but a half-built system requires even greater care to make sure that faculty are properly supported in research functions. If the upper-administration of the university has scientific and engineering research experience, that may simplify communications and leadership requirements during the development phase. If there is a lack of such background, new leadership will be required. The step-function program development of this proposal may help justify the early strengthening of research infrastructure support systems. A critical part of proposal preparation, review, site-visit, and program funding selection is the demonstration by the institution to provide a strong overall environment for the conduct of expanded programs for doctoral study and research.

EVALUATION CRITERIA

The basic philosophy of this program is that in a period of limited resources, all HBCUs will not be able to develop nationally competitive research programs. Criteria are needed for selecting institutions that will be supported in the proposed programs as well as for determining the progress of institutions after an award has been made. In this section, a set of criteria are to be described that can be used to accomplish the outcomes previously discussed.

To build a competitive program, a HBCU must show that it has had previous successes that would suggest that it is prepared to accept this additional charge. This might be accomplished by preparation of the following documentation:

a) number of active research faculty with demonstrated productivity as measured by publications in refereed journals;

b) record of the institution in producing Black students who have pursued advanced degrees in science or technology;

c) history of successful performance on previous competitive research grants;

d) presence of a core faculty with competitive scientific ideas; and

e) quality of the graduate research programs.

Any HBCU which meets the above criteria will be eligible for the program. Those institutions that meet the above criteria would submit a grant application that defines the general scientific and technical areas to be investigated. The proposal should contain sufficient technical detail to judge the merits of the program. The proposal should describe the faculty that will establish the core group around which the program will be built. It should also describe what additional personnel may be needed to effectively implement the program. Mechanisms for support of new personnel should be delineated.

The institution must describe its financial and administrative commitment to the research program. The financial commitment can take various forms, including a combination of indirect cost return to the principal investigator or the department where the research idea originated, allocation of space, and allocation of scientific and administrative personnel. The description of the administrative commitment must contain the procedures that will be established to expedite researchers' timely performance on the grant.

The grant application should define how undergraduate students will be identified and recruited to participate in the program, the type of educational experience that is planned, as well as the mechanisms for making up any deficiencies that could hamper their intellectual development. The program should be sufficiently flexible that outstanding students are educated in an expeditious manner.

Grants will be judged on their scientific quality. The institution must describe and define its goals and the means to attain those goals. The evaluation of grants should occur in three phases. Each institution's record should be evaluated, and the top ten rated HBCUs be selected for the second round of competition. In the second round, the five institutions with the best overall plan of scientific ideas, and goals and objectives, as well as administrative structure should be selected for site visits by an evaluation team.

On a site visit to each institution, the evaluation team should meet with the faculty, students and administrators to evaluate the institution's commitment and opportunity to develop competitive research programs. The site visit should include a member of the program staff of the federal agency that would fund the program as well as Black scientists and other administrators. The five grants would be ranked and those that have the necessary potential would be funded for a five year period. The proposals would be renewable for another five to ten years after detailed evaluation.

During the initial five year period, the program would be reviewed annually by an on-site team. This site team would evaluate how well the university is proceeding with its plan. It would attempt to identify any problem limiting the development of the research effort. The site team would have the authority to recommend termination after further review. Its report would be transmitted to the funding office, the president of the university, the board of trustees, and the director of the program.

There are three measures of success for a program of this type. These are:

. Research publications

. Successful graduation of students

. Successful pursuit of competitive research grants

Realistically after five years, the program should clearly show an increasing trend of productivity for all three items or it should not be renewed for a further five-year period. After fifteen years in the program, each institution would be terminated from the program.

GOALS OF THE PROPOSED PROGRAM

The Goals of the proposed program are:

1. To develop nationally competitive research programs at HBCUs.

2. To significantly increase the number of Black Ph.D. scientists and engineers.

3. To establish state-of-the-art national research facilities at HBCUs.

4. To increase the role of Black scientists and engineers in entrepreneurship.

RECOMMENDATIONS

1. The programs discussed within this document should be funded from currently available authorizations.

2. Each program area of every federal funding agency should provide significant support for this program.

3. Although the initial contract would be for five (5) years, it is imperative that each program be federally supported for a period of at least fifteen (15) years.

4. Industry should support the HBCUs in a collaborative effort to reach the goals listed in this document.

5. An external review committee should be established to monitor the impact of each new program upon

    (A) Doctoral Programs

    (B) Faculty Recruitment and Development

    (C) Administrative Structure

    (D) Institutional Support of the Program

    (E) Physical Facilities

    (F) Cooperative Interactions with

        (a) other educational institutions

        (b) governmental laboratories

        (c) industrial corporations

COST ANALYSIS

In order to develop first-rate graduate research programs and establish Research Institutes, it is necessary to have state-of-the-art instrumentation and the best possible professional personnel.

Four budgetary categories reflect those elements necessary to achieve superior research institutions in science and technology; 1) Implementation Programs; 2) Graduate Research Programs; 3) Major Research Instrumentation, and 4) Research Institutes.

This preliminary cost analysis is predicated upon the assumption of achieving full-scale operation in terms of facilities, personnel, and equipment at the end of the first five (5) years. The second five years is intended to operate at cost with inflation increases, with the exception of special purchases, such as major instrumentation. Thereafter, the graduate research program support is to be scaled down in no less than a five-year period.

The proposed Research Institutes should, however, be maintained at cost with inflation increases, with the exception of special or emergency requests.

1. IMPLEMENTATION GRANT

In order to effectively initiate the establishment of these graduate research centers of excellence and the supporting Research Institutes, preliminary funding for personnel, renovation, travel, infrastructure development, etc. is required.

It is estimated that the sum required to make all the necessary preparations is $500,00 per site.

Grant Request Per Site: $500,000

2. GRADUATE RESEARCH PROGRAM (FIRST YEAR)

Overall Cost Analysis

Program Component

Human Resources		Programs	
1. Faculty Permanent (4) Visiting (2)	150 K	1. Faculty Research Programs (4)	200 K
		Indirect Costs	113 K
2. Research Faculty (4)	144 K	2. Seminar and Colloquim Programs	21 K
3. Graduate Students (8 Full-time)	136 K	3. Annual Review and Future Planning	5 K
4. Tuition and Fees	56 K		
Fringe Benefits and Overhead	304 K		
Subtotal	912 K	Subtotal	339 K

4 (Four Program Components x 1,251 K)

Total Cost Per Site: 5,004 K

3. MAJOR RESEARCH INSTRUMENTATION

According to a recent NSF study of academic institutions, one-fourth of major research instrumentation in the U. S. is obsolete. There is a particularly dire need for substantive major equipment purchases if these institutions are to maintain viable research programs. The instrumentation situation of the institutions involved in this proposal is more severe. Therefore, an initial major investment of 1.5 million is requested in order to develop the facilities to support first-rate graduate training and research.

Amount Requested Per Site: 1,500 K

4. RESEARCH INSTITUTES

It is widely recognized that major research facilities impact the quality of graduate research at academic institutions. Examples of such cooperative arrangements are the University of California/Lawrence Berkeley Laboratory, University of Colorado/JILA, etc. In order to accelerate the rate at which similar quality is achieved at historically Black institutions, it is recommended that Research Institutes be established and maintained at each of the funded graduate research sites. These Research Institutes would reflect the unique resources and potential of each graduate institution. It is recommended that these Institutes be administered independently of the associated academic institutions. Several kinds of advantages which accrue to the institutions associated with Research Institutes are the following:

1) Concentrate totally on the development of a modern research facility.
2) Provide accountability in research productivity.
3) Research support resource for the academic community, i.e., collaborative research programs, etc.

Research Institute Budget

1st Year

PERSONNEL

Director	80,000
Associate Administrative Director	60,000
Director's Administrative Secretary	25,000
Associate Directors (2) (60,000 each)	120,000
Admistrative Assistant/Secretary (17,000 each)	34,000
Research Technician	34,000
Research Associates (2) (25,000)	50,000
Subtotal	403 K
Fringe Benefits (25%)	101 K
	504 K
*Overhead (100%)	504 K
Subtotal	1,008 K

PROGRAMS

Two of the four research areas each initiated originally at 100,000 (exclusive of major instrumentation)	200 K
TOTAL	1,208 K per site

FACILITIES AND PLANT

*It is anticipated that the overhead be used for leasing and/or renovating facilities for these purposes.

FIVE YEAR SUMMARY COST ANALYSIS

		Amounts in Millions (M)
IMPLEMENTATION GRANTS:		
(500 K x 4 Sites)		2 M
MAJOR RESEARCH INSTRUMENTATION:		
(1,500 x 4 Sites)		6 M
GRADUATE RESEARCH SITES (4):		
1st Year (5,004 K x 4 Sites)	20.0 M	
2nd Year	22.0 M	
3rd Year	24.2 M	
4th Year	26.7 M	
5th Year	29.3 M	
TOTAL	122.2 M	122 M
RESEARCH INSTITUTES (4):		
1st Year (1,208 K x 4 Sites)	4.8 M	
2nd Year	7.8 M	
3rd Year	9.6 M	
4th Year	11.1 M	
5th Year	12.1 M	
TOTAL	45.3 M	45 M
Funding Total (1st Five Years for four sites)		175 M

THE UNDERGRADUATE PROGRAM COMPONENT

Plan to Strengthen Undergraduate Education Programs
in
Historically Black Colleges and Universities

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SUMMARY

Minorities are significantly underrepresented in science at every educational level and are not participating fully in science policy discussions and decisions. There is serious concern about the quality of science instruction and research opportunities available to underrepresented minority students, particularly those enrolled in predominantly Black institutions. In addition, mechanisms are needed to periodically and independently assess the status of undergraduate science programs and offerings at minority institutions. There is just concern about the major attrition of minority students enrolled in science programs at the college level, especially during and immediately following the freshman year.

To address these concerns, an improvement plan spanning twenty years has been developed which focuses on the undergraduate level. This plan has two major objectives:

1. To increase the number of minority students who successfully complete Ph.D. programs in quantitatively-based science fields.
2. To improve the quality of science programs at selected minority institutions by increasing:
    - the number of faculty in key areas,
    - research opportunities for faculty and students, and
    - opportunities for faculty to earn the Ph.D. degree or to enhance their skills in critical areas.

It is proposed that fifteen minority institutions will be selected through a competitive process to recruit approximately 50 exceptional minority students (for a total of 750) to participate in a high quality academic science program. This program includes a pre-freshman summer, a special retention program (especially during the freshman year), opportunities for research at the undergraduate level, and guaranteed graduate support for two years in key identified science areas (e.g., physical, mathematical, and computer sciences).

It is projected that of the original 750 students, 375 will remain in undergraduate programs in the areas identified, that 200 will be admitted to Ph.D. programs, and that 120 will complete the Ph.D. degree in a quantitatively-based science field. (Currently a total of 39 Ph.D.s are being produced in these areas).

To prepare the high quality graduate desired, it is essential that enhancement of faculty curriculum occur in key areas. Minority institutions meeting the following criteria will be encouraged to compete for funds to implement the proposed program:

1. Offer the B.S. degree in at least three of the following areas: biology, chemistry, physics, mathematics, and computer science.
2. At least 50% of the faculty in the areas above should have the Ph.D. degree.
3. At least 30% of the faculty should be actively engaged in research and publishing in refereed journals.

It is expected that institutions selected will have achieved the following success at the end of ten years:

1. Offer a degree in computer science.
2. Seventy-five percent (75%) of the faculty will have the Ph.D. degree.
3. Sixty percent of the faculty will be actively engaged in research and publishing in refereed journals.

It is expected that at the end of the program, a significant number of students will have also been prepared to enter Ph.D. programs in other science-based fields, professional schools, and science teachings. In addition, some students will enter industry or other positions in scientific and technological fields. However, pursuit of advanced training in the quantitatively-based areas will be stressed throughout the undergraduate years.

All proposals will include support for external evaluation, with visitation occurring every two years.

Recommendations

Provide funds sufficient to carry succeeding student groups through the described program and to effect the changes proposed in the undergraduate programs at the selected institutions. Specifically, provide support for the concurrent group as follows:

1. INCREASE FLOW INTO SCIENCE AND TECHNOLOGY $140 Million

75% Freshmen $\xrightarrow{\text{9-Year Cycle*}}$ 120 quantatitively-based Ph.D.s/year**

2. ENHANCE UNDERGRADUATE PROGRAM QUALITY $ 35 Million

(Provides for the addition of computer science major at 15 institutions; an increase in the number of faculty engaged in research from 30% to 60%; an increase in the number of faculty with Ph.D. degrees from 50% to 75%; an increase in the size of the science faculty by 20%; external visitation and evaluation)

*Estimated cost of 9-year cycle beginning in 1985 is $10 million.

**Does not include those who will opt for other science based fields at various decision points in the cycle.

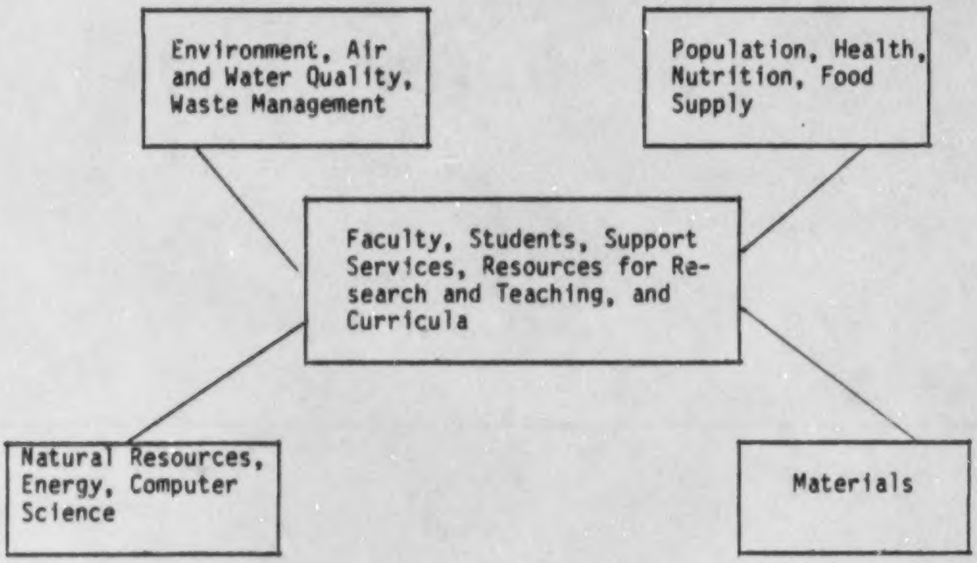
INTRODUCTION

The national problem of underrepresentation of minority Ph.D. degree scientists in critical scientific areas of national concern (Population, Materials, Natural Resources, and Productivity) is common knowledge to all experienced in these fields of science. The majority of Ph.D. trained minority scientists received their undergraduate training at minority institutions. The track records and current data indicate that Black institutions, for example, are more successful in training Black youth than any other type of institution. Sensitivity to the needs of Black students in America is one of the main strengths of the faculty at Black institutions. This sensitivity is often coupled with dedication and commitment to provide the positive energy necessary to inspire and motivate Black students to lofty scientific goals. Another important aspect of this phenomenon is the preponderance of role models for aspiring Black scholars and professionals. The small class sizes usually found in Black institutions increase the probability of one-on-one student teacher interactions with all the attendant benefits. Those interactions are heightened in importance by the multicultural mix of the faculty at most historically Black institutions, facilitating the transition between an often largely Black environment to a white majority society. There is then sufficient justifications for investing funds in the improvement of Black and other minority undergraduate institutions for the purpose of training greater numbers of minorities in the sciences.

With the above justification for the existence of Black institutions aside, one must devise a method to increase the pool of capable students interested in science and technology careers. Given high quality science programs at minority institutions, the problem is reduced to one of marketing talented minority youth on enrollment at the minority institutions in technical areas in unprecedented numbers.

Outlined below is a plan spanning twenty years with the purpose of attracting and retaining outstanding minority students to minority institutions through a program of high quality scientific training. The goal of this plan is to increase the numbers of minority graduates enrolling in Ph.D. programs nationally, in the quantitatively-based science fields of biochemistry, biology, chemistry, mathematics, physics, and computer science.

The minority undergraduate institution is seen as the core of the plan to increase contributions of minority scientists in the critical areas of societal importance as diagrammed below.


Environment, Air and Water Quality, Waste Management
Population, Health, Nutrition, Food Supply
Faculty, Students, Support Services, Resources for Research and Teaching, and Curricula
Natural Resources, Energy, Computer Science
Materials

Minority Institutions

RATIONALE

The economy of the United States is heavily grounded in science and technology. The high standard of living and quality of life enjoyed in this country when compared with other nations of the world are due largely to advances made possible by applications of science and technology, including agriculture and health. And yet in this society, which is increasingly defined by science and technology, there are groups which enjoy fewer of the advantages and which often bear a disproportionate share of the costs of our technological advances. American Indians, Blacks, Mexican Americans, and Puerto Ricans are groups which are underrepresented in science and engineering and overrepresented among U. S. citizens who are (1) alienated from science and technology; (2) impacted negatively by changes brought on by technology; and (3) powerless to influence the rate and direction of technological change.

At the same time, these groups represent a growing part of the population of young persons who will be available to push forward the frontiers of science and resource our technological workforce in the next 20 years. These citizens will make personal and collective decisions which require knowledge of science and technology. Will they have the knowledge necessary to make these decisions? Will they have the basic grounding in science and technology to sustain our quality of life, to spread the advantages brought on by technology, and to minimize the disadvantages which will ensure a better standard of living for those who inhabit our fragile and interdependent planet?

In order to ensure such representational training, it is necessary that minority institutions be provided opportunities:

1. To assume responsible roles in a technologically-based society.
2. To maintain scientific and technological development.
3. To develop the economic potential of minority communities and improve the standard of living for vast segments of the population.
4. To meet societal needs, to provide human resources for a technologically based workforce, to strengthen the national economy in a changing world marketplace, and to address energy, health, environmental, population, and quality of life issues as experts and as citizens.
5. To fulfill the responsibility we face as a modern industrial nation to assist developing countries in alleviating the problems which hinder their development and progress.
6. To affect the rate and direction of technological change; to impact those policies in a way that determines the distribution of resources for science and technology and the priority to be addressed.
7. To apply the knowledge borne of diverse cultural experience toward advancement of the frontiers of scientific knowledge and its applications.
8. To fulfill our uniquely human need to explore and understand the nature of the physical universe.

In order to accomplish these ends, we must increase the overall output of scientists and engineers currently underrepresented and increase the overall levels of scientific and technological literacy in minority communities. Not only must knowledge of science and technology be increased for the average citizen, but especially for those who assume positions of leadership and influence in our society - judges, lawyers, politicians, journalists, teachers, business persons, financiers, and the like. To ensure that this will happen, it is not sufficient that individuals training for these positions increase the amount of science and technology to which they are exposed, but also that there is improvement in the quality of offerings available to such individuals at every level.

At the college level, we must increase institutional capability to carry out these educational objectives; especially, to increase the numbers of minority scientists and engineers. For this reason, we propose a plan which will have as its primary focus, the development of a cadre of Ph.D. professionals to address the greatest areas of underrepresentation in fields having the greatest national need.

We have focused on defining those elements which seem to be key in addressing the needs of highly talented, science-capable minority students, identifying key decision points and times/causes of special risk. We have suggested interventions to decrease the risk of losing these students from the system and of providing an array of enrichment activities which might foster/stimulate/solidify commitment to graduate study and research careers in the sciences.

The objectives we have articulated for the college group have been broad. We believe, however, that in improving the overall climate for science within minority institutions to a level necessary to produce Ph.D. scientists, we increase the opportunities for fulfilling the multiple objectives we have defined.

BACKGROUND DATA AND SUPPORTING STATISTICS

Minority Participation in Science

American Indians, Blacks, Mexican Americans, and Puerto Ricans are underrepresented in quantitatively-based fields in comparison to their representation in the general population.

TABLE 1. 1980 U.S. Population, Science/Engineering (S/E) Workforce, and Doctoral Scientists and Engineers by Race/Ethnicity

Race/Ethnicity	% In Population	% In S/E Workforce	% In Doctoral S/E
White	79.6	95.0	89.0
Black	11.5	1.9	1.1
American Indians	0.6	a	b
Asian/Pac Isl	1.5	2.8	6.6
Spanish Origin	6.4	a	b
Other/No Response	0.4	a	b
	100.0	100.0	100.0

NOTE: Categories with "a" total 0.3% of the 1980 Sci/Eng. workforce. Categories with "b" totaling 3.3% of the Doctoral Sci/Eng.

SOURCE: National Science Foundation, U. S. Scientists and Engineers, 1980, NSF 82-314.

Differences in attrition rates between whites and underrepresented minority groups at various points along the educational ladder explain their relative representation in the S/E workforce and the doctorate S/E pool. For example, for every 100 whites who enter first grade, 83 complete high school, 23 complete college, and 8 complete graduate or professional school. By contrast, for every 100 Blacks who enter first grade, 72 complete high school, 12 complete college, and only 4 finish graduate or professional school.

During the first half of the 1970's, there was a large increase in Black enrollment (that coincided with an expansion of federal legislation and policies), to the point that by 1975, the percent of Black high school graduates enrolling in college was the same as that for whites. However, during the latter half of the 1970's, the number of Blacks who enrolled in college remained essentially unchanged even though the pool of Black youth in the college age group increased by 20%. In fact, between 1975 and 1980, the percentage of Black high school graduates enrolling in college declined from 32% to 28% with a similar decrease for Hispanics from 35% to 30%.

In 1980, Blacks represented 10% of all undergraduates and less than 6% of the graduate student body, while comparable figures for Hispanics was 5% at the undergraduate level and 3% at the graduate level.

In 1980, 34% of Black high school seniors had taken remedial mathematics and only 20% had enrolled in advanced or honors mathematics. Figures for American Indians and Hispanics are even less.

Further, there is a direct correlation between socio-economic status and the percentage of advanced or honors mathematics courses taken. (Almost 70% of Black college-bound seniors in 1981 came from families whose annual income was less than $18,000). Within each undergraduate minority group, there is strong correlation between family income and SAT-M and SAT-V scores.

Among 1981 college-bound seniors, the percentage of undergraduate minority group students expressing an interest in studying science was in each case less than the percentage of all college-bound seniors expressing an interest in studying science. (15% for all, 13% for Blacks, 14% for American Indians, 12% for Mexican Americans, and 13% for Puerto Ricans).

In 1981, Blacks received approximately 4% of the degrees awarded in the physical sciences, 2% of the master's degree, and only 1% of the doctorates in this area.

Table 2 shows the actual degree attainments for Blacks at each level in the critical areas of the physical sciences, mathematical sciences, and computer specialities.

TABLE 2: Science and Engineering Degrees Received By Blacks in Selected Fields, 1980 - 1981.

Field	Bachelor's	Master's	Doctorates
Physical Sciences	906	107	28
Mathematical Sciences	584	67	9
Computer Specialties	786	70	2

SOURCE: National Science Foundation, "Women and Minorities in Science and Engineering", Washington, D.C., 1984.

Among 1982 science and engineering doctorate recipients, Blacks were more likely to have loans and non-federal support as a major source of graduate support than any other group.

In 1980, minority group members represented only 11% of all post-secondary teachers while representing more than 18% of the total undergraduate enrollment and 11% of the graduate enrollment.

Minorities are not significantly represented in national science academies, on national advisory boards, in leadership positions in science-oriented agencies, or on Congressional science-oriented committees or the staffs of such committees. Hence, they are not in a position to have significant impact in the formulation of science policy and on science-based decisions even though the community is clearly affected by such policies and decisions.

Statement of Problem Areas

Based on the information provided in the preceding section and on other available data, it is clear that minorities are significantly underrepresented in science at every educational level and that they are not participating fully in science policy discussions and decisions. There is also concern about the quality of science instruction and research opportunities available to underrepresented minority students, particularly at predominantly minority institutions. In addition, mechanisms are needed to periodically and independently assess the status of undergraduate science programs and offerings at minority institutions.

There is also concern about the major attrition of minority students in higher education, especially during and immediately following the freshman year in college.

The general lack of science awareness and appreciation of the contributions of science within each of the underrepresented minority communities is to a large degree responsible for the low participation/representation rates of these groups in the S/E workforce. However, there are many barriers (institutional, societal, personal) that operate to prevent the full participation of minorities in science and science policy-making.

The numerous recently released reports addressing the need to improve the quality of science and mathematics education within the public school system do not pay particular attention to the plight of minority students in science and mathematics.

There is a technological revolution under way that will require a sizable portion of our workforce to be technically well-trained and will extend the list of basic competencies necessary to function successfully in society to include some level of computer literacy.

Finally, there are many issues emanating from the application of science and they are becoming increasingly complex. Their successful resolution requires a citizenry that is scientifically literate. At the current time, important decisions are being made without proper representation of minority group interests or perspectives.

PROGRAMMATIC THRUST

To address the problem areas identified as it relates to the ultimate goal of this document, the undergraduate committee proposes as objectives:

1. To increase the number of minority students prepared a) to enter Ph.D. programs in science,* with particular emphasis on the quantitatively based sciences; b) to enter professional schools; c) to enter interdisciplinary science based career options (e.g., Geophysics); d) to become science educators; and e) to acquire jobs in science and technology at the B.S. level.

2. To increase the quality of science training at selected minority institutions by increasing faculty numbers in identified key areas; to provide research opportunities for faculty; and to provide opportunities for faculty to earn the Ph.D. degree or to have further training in identified areas of national need.

3. To expand the curriculum offerings to include degrees in computer science.

4. To provide programs for increased science awareness in the community.

5. To increase the involvement of the minority community in the making of science policy.

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*Physical, mathematics, computer and life sciences.

MECHANISMS FOR IMPLEMENTATION

The following model represents a workable plan spanning twenty years designed to accomplish the goals stated in the programmatic thrusts outlined above.

Goal 1.

Fifteen minority institutions will be selected thorugh a competitive process to recruit approximately 50 outstanding minority students (750 total) to participate in a high quality academic program which includes a pre-freshman summer, a retention program (especially during the freshman year), opportunities for research at the undergraduate level, and guaranteed graduate support in key identified science areas. Emphasis will be placed on students pursuing the Ph.D. degree in the quantitatively based science fields (includes appropriate life sciences).

It is expected that the students selected will have at least a 550 SAT mathematics score and an interest in pursuing a career in the physical sciences, mathematics, or computer science,* and will be prepared to enter college-level science courses. The pre-freshman summer program will consist of courses in computer science, mathematics, physics, and communication skills. During the freshman year, students will receive intensive career and academic counseling and tutors will be made available, if needed. The importance of good study habits, establishing academics as the number one priority, and a willingness to commit 8 to 9 years to their scientific training will be discussed in individual and group meetings so that the student will be fully aware of what is expected of him or her. Parental involvement is necessary at this stage.

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*Model based on these areas for the purpose of cost analysis; the results may be factored up or down as necessary. The effect of the life sciences is not included in the model calculations.

In the summer between the freshman and sophomore years, opportunities for research or work in a science-based setting will be made available to the student. Research sites include the home institution, other institutions, national laboratories, and industry.

During the junior year, opportunities for research and study away from the home institution will be available. These would include co-op programs, study and research programs at other institutions, or semesters at national laboratories.

Because of the critical national need, students planning to pursue careers in the quantitatively based sciences will be identified during the junior year. Two year fellowships will be awarded to those students who are interested and prepared to successfully pursue graduate study in the identified areas upon completion of the B.S. degree and acceptance into a Ph.D. program. It is expected that the student will gain as much research experence as possible as an undergraduate.

It is projected that of the original 750 students, 375 will have remained in undergraduate programs in the areas identified, that 200 will be awarded two-years fellowships, and that 120 will complete Ph.D. degrees in the quantitatively based science fields. The program will have also prepared students to enter doctoral programs in the natural sciences, interdisciplinary sciences, professional schools, and science education. It is expected that some students will enter industry or other positions in scientific and technological fields, however, pursuit of advanced training wil be stressed throughout the four undergraduate years. Funds would be available to carry out 10 succeeding groups of students through the program described above (i.e., for years 1985-2005). A program director, with staff, would coordinate the activities. Identification of research sites and opportunities for study at other institutions would be included in the responsibilities of the program director.

Goal 2.

To prepare the high quality graduate described in Goal 1 above, it is essential that enhancement of faculty and curriculum occur in key areas. Minority institutions meeting the following criteria will be encouraged to compete for funds to implement the program described above.

1. Offer the B.S. degree in at least three of the following areas; biology, chemistry, physics, mathematics, or computer science;
2. at least 50% of the faculty in the areas above should have the Ph.D. degree;
3. at least 30% should be actively engaged in research and publishing in refereed journals; and
4. faculty should have a commitment to undergraduate teaching and research training.

Institutions selected in the competition will be variable in their degree and curriculum offerings (i.e., Ph.D., M.S., B.S. in the various areas), however, it is expected that all institutions selected will have the following record of success at the end of ten years:

1. Offer a degree in computer science;
2. Seventy-five percent (75%) of the faculty will have the Ph.D. degree;
3. Sixty percent (60%) of the faculty will be actively engaged in research and publishing in refereed journals.

Funds would be made available to these institutions in order to:

1. add new faculty in areas of need. These faculty would be provided with seed money for research;
2. allow faculty currently at the institution to pursue the Ph.D. degree;
3. allow faculty to take sabbatical leaves to perform research or post-doctoral study to enhance their background in critical areas of national need;
4. allow faculty to receive training in critical skills areas (e.g., computer science, teaching methodologies, etc.); and
5. support endowed chairs in the sciences, mathematics, and computer science.

It is expected that all proposals would include funds for an external evaluation of the programs. The external visiting committee should include at least six members. Visitation and evaluation should occur every two years.

Goal 3.

There is a need for increased awareness within the minority communities of science and technology, in general, as well as the potential impact of science and technology on minority communities. This can be accomplished via a number of specific activities which include:

1. Increasing minority attendance at science museums (and including ideas for particular interest and concern to minority persons among exhibits;

2. making concepts and resources available through science and technology centers to minority communities (e.g., establishing store-front science and technology centers, mobile science centers, science exhibits at shopping centers or in abandoned school buildings);
3. increasing the number of minority science journalists (e.g., by establishing a cooperative program between Clark College's Mass Communications program and the science writing program at MIT);
4. increasing the coverage of science and technology topics in minority media;
5. increasing recognition of accomplishments and contributions of minorities in science and technology by minority media and advocacy groups; and
6. developing programs that enable parents and children to explore science and technology together that can enhance student performance (e.g., family math project).

Goal 4.

With the growing impact of science and technology on minority communities, minority leadership (e.g., Black and Hispanics mayors, members of the Black and Hispanic caucuses, etc.) must be educated about science and technology issues. We recommend that a series of conferences (e.g., at Harvard, Bellagio, Aspen, etc.) be held focusing on promoting cooperation among minority leaders and minority scientists and engineers in areas concerning science and technology.

PROGRAM COSTS

The total costs to accomplish the goals of this improvement plan are $175 million (M) over the twenty year period. Taking 120 students successfully through the 9-year cycle beginning in 1985, would cost @ 10 M; the total costs for students for the entire twenty years would be $140 M, $80 M for graduate students, and $60 M for undergraduate students. The total costs for faculty and institutional improvement would cost $35 M. The details of the cost estimates are given in Appendix G.

RECOMMENDATIONS

The specific recommendations of the undergraduate committee for increasing participation of minorities in scientific and technological fields (pre-college, undergraduate, graduate, and cooperative programs are:

1. To increase the pool of capable students enrolling in Ph.D. level quantitatively-based scientific fields by activating an array of programs and activities aimed at recruitment, retention, and training high quality undergraduates.
2. To improve the faculty at minority institutions by adding or upgrading faculty; providing for critical skills enhancement; improving support infrastructure; providing endowed chairs; and providing sabbatical research opportunities.
3. To develop state-of-the-art curricula at minority institutions and to include degrees in computer science in their offerings.
4. To involve the minority community in the making of science policy.
5. To fund a long range program spanning twenty years with built-in provisions for evaluation at a minimum cost of $175 M for all components; and that a minimum of 15 minority institutions be involved to implement the above four recommendations.

APPENDICES

APPENDIX A: CHARACTERISTICS OF A HIGH QUALITY FACULTY

1. Faculty
    - Doctoral degree
    - Actively engaged in research.
    - Publishing in refereed journals.
    - Dedicated to undergraduate teaching and willingness to involve undergraduates in research.
    - Sensitive to the special needs of minority students.
    - Actively seeking external support.
2. Supportive environment
    - Viable infrastructure

APPENDIX B: CRITERIA FOR STUDENTS
(Exceptions Upon Entry at the College Level)

- Minimum of one (1) year each of high school chemistry, biology, physics, and math through pre-calculus (Algegra I & II, Geom., Elem. Anal., and a knowledge of a computer science language).

- Demonstrated interest in science (e.g., hobbies, science fairs, science museums, summer jobs in a science environment, etc.).

- Acceptable academic performance levels (standard examinations, GPA) that allow for successful enrollment in calculus and science courses on the college level.

- Positive self-image and maturity.

- Good communication skills (verbal and written).

APPENDIX C: SUPPORT SERVICES FOR STUDENTS

1. Academic, personal, and career counseling;
    - freshman academic support office
    - student affairs
    - financial aid
    - career counseling and placement.
2. Student Activities (student government, intramural sports).
3. Supportive living environment (personal and academic).
4. Adequate security and protection.
5. Health and Nutrition programs (psychological counseling, medical services, high quality food services).
6. Student science-based organizations.

APPENDIX D: FACULTY RESOURCES

1. Seed research money for junior faculty.
2. Endowed Chairs.
3. Adequate academic and administrative computer hardware.
4. State-of-the-art teaching and research equipment.
5. Adequate teaching and research facilities. (Office, laboratory, and research space)
6. Travel funds.
7. Adequate learning resources. (Library holdings, computer software, videodiscs)
8. Support for periodic review, revision, and development of curricula.
9. Support of external evaluation.
10. Adequate support staff.

APPENDIX E: CURRICULUM

1. State-of-the-art curriculum offerings (including computer sciences);
    - courses, mini-courses, seminars, workshops, visiting lecturers, co-op programs
    - wide variety of offerings.
2. Extensive use of computer technology for curriculum support.
3. Opportunities for undergraduate research.

APPENDIX F: MECHANISM FOR INCREASING MINORITY Ph.D.s

Mechanisms for increasing the number of minority Ph.D. scientists in the quantitatively-based sciences.

There were 7,000 students with SAT-M 550 in 1981 (reference year). Only 13% of all college-based Black students indicated science as an intended area of study.

Assuming the pool of students attracted to minority institutions and interested in science is 750, 15 minority institutions would competitively recruit 50 of these students each.

Pre-freshman summer - 750 students

Freshman Year - Special retention program

Junior Year - Early commitment to graduate school

Senior Year - 375 graduates in science will form a pool for future Ph.D. scientists (compared with 2,276 total in reference year)

First Year Graduate School - 200 will enroll in Ph.D. graduate science programs at minority/majority institutions.

APPENDIX F: MECHANISM FOR INCREASING MINORITY Ph.D.s
Continued

Projections 1985 - 1994

1985		1989		1989		1994
750	(50%)	375	54%	200	60%	120

2 - 3 fold increase in 10 years over reference year; 1,200 additional minority Ph.D. scientists by 2004 at a rate of 120 per year beginning in 1994 for 10 years.

Currently

Only 39 Ph.D. graduates in physical science, computer science, and mathematical sciences in reference year

At current rate, 30 years would be required to produce the same results.

APPENDIX G: COST ANALYSIS FOR INCREASING MINORITY Ph.D.s

Year	Activities/Cost		
1st	Pre-freshman - 8 week summer program (Computer Science, Summer Programs, Communication Skills, Physics, Math) 10 K/teacher x 4	=	$ 40 K (include 25% F. B. rate)
	Stipend 1 K each/50 students		$ 50 K
	Projected Director plus support/yr.		$ 100 K
	TOTAL (includes indirect costs @ 50%)		$ 250 K
	Freshman academic year/50 students		$ 20 K
2nd	Pre-sophomore summer program (External experience in science arranged by Project Director)		-0-
			$ 270 K
	15 institutions x 270 K - $2.05 M		
3rd	(Junior year away, co-op fellowships (25 @ 10 K for all 15 institutions)	=	$ 250 K
	TOTAL - Undergraduate/yr.		$ 4.3 M
5th	First year graduate school in science; $12.5 K x 200 students	=	$ 2.5 M
6th	Second year graduate school	=	$ 2.5 M
	Approximate Total	=	$ 10 M/Yr.

Total 10 Years = $138 M (78 Million for graduate student support, 60 Million for undergraduate student support

APPENDIX G: COST ANALYSIS FOR INCREASING MINORITY Ph.D.s Continued

By 2004, 1200 minority Ph.D. scientists will have been added; computer science degree programs will be in place at 15 institutions. By 1995, 75% of faculty in selected departments will have doctoral degrees, 60% will be actively engaged in research, 25% will have critical skills enhancement experiences. All faculty in selected departments will have been impacted.

APPENDIX H. OTHER OUTCOMES

An additional 120 minority Ph.D. scientists will be employed by government, industries, universities, and other research entities per year. Forty-seven percent (47%) of original 375 B.S. graduates will pursue other careers such as professional schools, pre-college education, etc. and assume positions affecting future science policy, etc. Forty percent (40%) of the 200 entering graduate schools in science will enter industry, professional schools, other interdisciplinary science areas, etc.

Strategies for Support

- $40 - 60 M needed to run programs for first 5 years.
- Establish non-profit organization to raise funds and administer funds of program (e.g., a science and technology foundation).

Benefits to Non-Selected Institutions

- Increase number of Ph.D. scientists who might teach at these institutions.
- Some of the 15 can serve as hosts for their undergraduate students interested in special research opportunities and in courses not offered at their home institutions.
- Overarching structure (i.e., non-profit funding or a national office for this effort) can assist their faculty/students in identifying/lobbying for special efforts on their behalf.

APPENDIX I: CRITERIA FOR ESTABLISHMENT OF HIGH QUALITY UNDERGRADUATE SCIENCE PROGRAMS AT MINORITY INSTITUTIONS IN 10 YEARS

- Undergraduate degree programs in at least three (3) of the following five science areas (Biology, Chemistry, Physics, Mathematics, and Computer Science).

	Area of Concern	NOW	THEN (1995)
1.	Undergradute Degree	60%	80% (add one-computer science, a priority)
2.	Faculty	NOW	THEN (1995)
	- Engaged in Research	30%	60%
	- Doctoral Degrees	50%	75%

Mechanisms

- Adding new faculty with Ph.D. degrees at a cost of	$100 K/faculty
- Providing seed research money for new junior faculty @	100 K/faculty
- Current faculty returning to school for docotral degree @	25 K/faculty
- Providing 1/2 sabbatical research leaves for current faculty @	20 K/faculty

APPENDIX J: COST ANALYSIS FOR MINORITY INSTITUTIONAL IMPROVEMENT IN 10 YEARS

Typical school with 1,500 undergraduates will have:

Biology	-	5 faculty	
Chemistry	-	5 faculty	
Mathematics	-	10 faculty	
		20 faculty	10 with Ph.D.s (50%) 6 engaged in research (30%)

Desired Outcomes in 20 Years:

80% of five areas -- add 4 faculty (Physics/Computer Science computer a priority) 75% with Ph.D. degrees.

60% in research (of 24 total) -- 15 faculty in research (9 needed to teach) 75% with Ph.D.s; need to add/upgrade 5 faculty to reach this goal.

Cost Analysis for Faculty Development:

Physics/Computer Science (3 @ $140 K + 1 @ 50 K)	=	$470 K
Add/upgrade 5 @ 100 K	=	500 K
New Researcher (1/2 sabbatical)	=	20 K
		$990 K
Critical Skills Enhancement (e.g., computer science teaching) 6 @ 20 K	=	$120 K
		1,110 K or 1.11 Million x 15
15 Schools x 1 M - $15 M		
Endowed Chairs (15 @ 1 M)	=	15 M

External Visiting Committee

1 visit/2 yrs. = 5 visits for 10-year period
6 team x $1,300/person x 5 x 15 schools = $600 K

Computer Systems Donated (Maintenance for Indirect Costs)

TOTAL FOR IMPROVING QUALITY OF SCIENCE PROGRAM IN 10-YEAR PERIOD = $32.1 M

APPENDIX K: INFRASTRUCTURE NEEDED

I. Student Component

A. Program director and staff.

B. Academic and career counseling.

- Professional societies (Mentor concept).

C. Living arrangements, health and food services, student activities, student professional groups.

D. Personal computers for the 750 students - industrial contribution.

E. Summer science-based experiences-industrial contribution (post-freshman summer).

F. Undergraduate research opportunities. (Use network institutions) assisted by the NSF and other grants; National laboratories (including NASA centers).

G. Seminars, conference presentations - professional societies and research grants.

H. Summer enhancement (foundations and corporate foundations).

I. Fellowships* -- government and industry (NASA, EPA, NSF, DOD, NOAA, DOE, IBM, HP, Exxon, DEC, GM, GE, Allied, McDonall Douglas, Mobil, Dupont, Goodyear, NIH, Monsanto, Eastman Kodak, Pfizer, Rockwell, Bell Laboratories, MCI, AT&T, Rolm, Ford).

*Each fellowship @ 25 K for 2 years, 4/industry for 25 industries, $100 K each - 75 for 8 agencies. Twenty-five (25) for state government (GA, NC, AL, MS, AL, TN, SC, FL, TX, VA, MD, PS, NY).

J. Science policy fellows (summer internships and short term spring internship). Foundations and agencies; coordinated by professional societies.

APPENDIX K: INFRASTRUCTURE NEEDED
Continued

II. Faculty Component

A. Critical skills enhancement.

Areas - Possible Support Sources

1. Policy internships - agencies (NIH extramural associates)

2. New skills (6 faculty/institution)

    - instrumentation (request industry to absorb costs for faculty to take their courses)

    - computing skills @ 20 K per person

    - information systems (ERIC, interlibrary, visits to library of congress, national library of medicine, etc.)

    - science teaching skills @ 20 K

    - career counseling workshops 2/institution @ $1,200

B. Computer Science Major

- local industry that can benefit from sending their personnel for updating their skills, problem solving for industry.

C. Seed money for new researchers.
(Federal agencies, high technology industry, etc.)

APPENDIX L: EXPECTATIONS OF "PARTNERS" IN THE PLAN

Expectations of Faculty

- perform quality research
- publish/present papers
- serve as consultants
- review proposals for funding agencies
- support/participate in local school and community affairs
- participate in science-based forums on science policy issues
- involve undergraduate minority students in research
- interact formally with students

Expectations of Minority Institutions

1. Recognize need for special effort in science/technology.
2. Recognize need for faculty/students to be engaged in research.
3. Recognize need for, and provide administrative infrastructure to ensure a high quality of life for students and faculty and for performing quality research.
4. President of fifteen (15) institutions should be willing to attend workshops outlining goals of the 10-year project, including understanding (and being committed to) redirecting indirect costs back into the support structure; assisting other minority institutions.
5. Recognize the possible need for special financial assistance for these students, given the long hours required to do science.
6. Recognize that quality science may mean a higher salary scale and maintenance costs.

APPENDIX L: EXPECTATIONS OF "PARTNERS" IN THE PLAN
Continued

Expectations of Governing Boards

- take the time to learn about the issues being addressed in this paper.
- willingness to secure funds necessary to build a permanent structure for this program.
- provide for space and building needs to support science programs.
- include in their membership persons knowledgeable about science issues.

Expectations of Professional Societies, NAS, etc.

- use AAAS/OOS model to establish comparable offices.
- include increasing minority participation in science among their major priorities.
- seek minority scientists to serve on their committees and their advisory panels.

APPENDIX M: OVERALL CONCERNS

1. Educating minority leadership on science and technology based issues (including Black mayors, members of the Congressional Black and Hispanic caucuses, heads of advocacy groups, mayors of cities with large minority populations) in small working groups with minority scientists and engineers (such as at Harvard, Bellagio, or Aspen).
2. Increasing community awareness via: (a) science museums, (b) science writing (e.g., Clark's Mass Communications/MIT Co-op), (c) Storefront science centers (e.g., mobile units, shopping centers, abandoned school buildings, (d) "Family-Math" projects, (e) increased publicity, recognition of accomplishments/contributions via the media about science/technological developments (minority newspapers, magazines, TV spots, etc.).
3. "Partnership" aspect of the 10 year project must be clearly articulated and highlighted (government/industries/foundations -- roles outlined for church, individual families, individual students, minority institutions).
4. Assisting minority mayors in forming science and technology advisory councils.
5. Establishing a data network among minority institutions.
6. Establishing a science and technology foundation to raise funds, administer programs, coordinate activities, support intellectual/philosophical base ("Think Tank").
7. All partners must be made aware of the length of time involved and the need for a sustained commitment (parents, students, others).
8. Computer companies will be approached for significant, long term contributions.

THE PRE-COLLEGE PROGRAM COMPONENT

Plan to Significantly Increase the Number of High School Students Selecting Careers in Science and Technology

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INTRODUCTION

There is a broad consensus that high quality science and engineering education is vital to the long-term interest of the United States as this country strives to strengthen its economy, its national defense, the quality of life and well-being of its citizens. It is evident that this Nation's future prosperity and security depends on whether it can maintain a sufficient number of adequately trained scientists and engineers to respond to national needs and priorities, presently and in the future.

Central to maintaining a sufficient number of scientists and engineers is to ensure that the pool of high school graduates capable of, and interested in pursuing studies leading to scientific and technical careers remain high. Three key questions deserve our most serious consideration. First, to what extent can we document that precollege training in mathematics and sciences will help enhance this needed pool of high school graduates? Second, if we take action to enhance this pool, what will be the consequences with respect to our social and economic well-being? Third, if immediate short term and longer-term actions are not taken to enhance representation of Blacks and other minorities in the total pool of high school graduates, what will be the consequences?

Following World War II, with the establishment of the National Science Foundation (NSF), the federal government clearly accepted a major role in science and engineering education. With the amendment of 1985, the statutory authority of the NSF (the agency that has assumed the predominant responsibility for science and engineering education) was expanded to include support for science, mathematics, and engineering programs at all levels. Thus, programs ranging from precollege education to graduate and postdoctoral research and training were recognized as important components in developing a scientifically literate citizenry, while providing support for a strong educational system for students to pursue careers in science and engineering.

While there is an urgent need to increase the understanding of scientific and technological issues, science and engineering education activities are at their lowest ebb since the pre-Sputnik era. The present posture of the executive branch that the federal government should exercise a reduced role in education hastens the move toward virtual scientific and technological illiteracy and jeopardizes U.S. science and technical preeminence. The report, Science and Engineering Education for the 1980's and Beyond (1980), points out several deficits and problems with the science and engineering educational system in the United States. Although the report is not a consensus document, it, along with other reports like, A Nation at Risk, Who Will Do Science?, a special report by the Rockefeller Foundation, Women and Minorities in Science and Engineering, a report from the National Science Foundation, and Educating Americans for the 21st Century, a report of the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, point to several deficiencies which must be addressed in an organized, concerted effort to reverse the present trends. Some highlights of these reports follow:

1. There are, at present, shortages of trained computer professionals and most types of engineers at all degree levels.

2. While progress has been made in increasing the representation of minorities, women, and the physically handicapped, these groups continue to be underrepresented in science and engineering fields.

3. There is an immediate problem of acquisition, retention, and maintenance of high quality faculty to teach science, mathematics, and computer science courses at the pre-college levels. In a recent survey of high schools in 44 states, the following were documented:

   - Ninety-five percent (95%) of the states reported shortages or critical shortages in physics teachers.

   - Eighty-six percent (86%) of the states reported shortages of chemistry teachers.

   - Ninety-six percent (96%) of the states reported shortages of mathematics teachers.

4. Nationwide, 50% of the teachers in science and mathematics were unqualified and do not meet minimum state certification standards.

5. Between 1971 and 1980, there was a 77% decline in mathematics teachers in training, and a 65% decline in science teachers in training.

6. Decreasing priority is being given to science and mathematics in the secondary schools in marked contrast to Germany, Japan, and the Soviet Union.

Most disturbing is the fact that many of our youth are unprepared to enter college in technical majors after five years of high school. The larger percentage of our nation's youth graduate from high school with no science or mathematics beyond the tenth grade. These students have essentially been eliminated from scientific and technical careers, resulting in a decreased pool from which future scientists and engineers can be drawn. For example, the reports cited above show that only thirty-three percent (33%) of the nation's schools offer more than one year of science and mathematics; at least half of the nation's high school graduates have taken only one year of biology and no other natural science; and at least half of the nation's youth graduate from high school with no mathematics beyond algebra.

These problems are particularly acute for minorities and other disadvantaged members of the population, particularly those who are located in large urban school systems. In 1980, only 39% of Black high school seniors had taken Algebra II as compared to 50% of the white students, and only 38% of Black students had taken Geometry as compared to 50% of the white students. The failure to take appropriate high school mathematics courses impacts minority student enrollment in science courses. Whereas 37% of white high school seniors had taken a year of chemistry, only 28% of Black students had enrolled in chemistry.

The insufficient science and mathematics training at the high school level directly affects the number of Black students who pursue math/science/technical majors at the undergraduate level. In 1977, of 22,187 bachelor degrees awarded in the physical sciences, only 665 were awarded to Blacks; 707 of 14,086 Bachelors degrees in mathematics were received by Blacks, and 2,413 of 53,516 Bachelors degrees in biology were earned by Black students. At the Masters degree level, the figures are worse; 93 of 5,282 Masters degrees in the physical sciences were earned by Blacks, 133 of 3,695 Masters degrees in mathematics, and 206 of 7,114 degrees in the biological sciences were awarded to Blacks. At the Ph.D. level, 140 of 8,654 degrees in the physical sciences, and 205 of 15,501 degrees in the biological sciences went to Blacks. Specific intervention programs targeted at minority student populations must be instituted at all educational levels -- elementary through graduate school -- if the number of minority science/math/technology Ph.D.s is to be increased.

Historically, Black colleges and universities have trained, and continue to train a significant percentage of minority scientists and pre-college teachers who work with large numbers of minority students. These institutions therefore, are in a central position to have an impact on the science training of minority pre-college students, and must play an integral role in science education activities. Specifically, they can play an active role in: a) research involving curriculum development and cognitive processing as it relates to minority student education, b) pre-service and in-service teacher training programs, and c) public information programs designed to educate the lay community and parents about careers in science and technology. Both the science and science education departments at HBCUs should become involved in this effort that will ultimately increase the number of minority students receiving Bachelors, Masters, and Ph.D. degrees in science/mathematics, and technology areas.

PRE-COLLEGE SCIENCE AND MATHEMATICS GOALS

What is needed is a stated operational goal for pre-college science and mathematics with an explicit description of barriers to these goals. The primary goal of pre-college science and mathematics is to increase the number of students with adequate science and mathematics skills to pursue options in professional careers in, or related to science and technology. This goal encompasses:

1. Student awareness of career goal options.
2. Student literacy in science and mathematics.
3. Student retention in programs to nuture needed science and mathematics skills

The barriers to achieving this goal can be clustered into three categories. At the core of the array of barriers is the student. Student succcess is most closely influenced by the teacher. The teacher functions within another set of constraints defined by the school. The schools themselves are subject to the wider influence of the community.

The Student Barrier

Students who leave high school with the science and mathematics skills required to pursue a variety of career options are those with high personal expectations and high learning responsibilities. They have nurtured a high interest in, and a positive attitude toward science and mathematics rather than an attitute of anxiety and insecurity. Their priorities include personal discipline and regular attendance in school. They seek ways to use their skills because of the previous success in the study of science and mathematics. They value their personal satisfaction gained from enhanced control of their personal world.

On the contrary, the absence of high personal expectations, a positive attitude toward science and mathematics, a high priority for academic performance, discipline, satisfaction in achievement, and a positive self-image illustrate student barriers that in particular, deny minorities access to professional careers in science and mathematics.

The Teacher Barrier

The teacher can be a positive bridge to student success, or a potential barrier to success. Teachers control the learning environment as they determine who does what, and for how long. In determining the "who", the teacher is a strong force in deciding what expectations will exist for student performance, or equivalently, the criteria that will be used to include or exclude students from challenging learning contexts. Thus, teachers influence the motivation of students, ranging from nuturing excitement to discouraging student interest. Also important to student motivation is the teacher's personal security or anxiety with science and mathematics concepts. Beyond motivation, however, the teacher controls student success by how they relate instruction to intended goals. The "for-how-long" links the teacher's use of instructional time available (teacher on-task time) with their expectations of students.

School Barriers

Schooling can be a potential barrier through its influence on the teachers' indirect control of students. A positive schooling influence is seen in those contexts in which the goals for schooling are clearly and unambigously stated, as well as widely accepted. Thus, the purpose of school is clear to all the participants -- the student, the teachers, the administration, parents and the community. Equally important to each of the participants are expectations.

These expectations require that schools provide access to appropriate curriculum and essential academic support systems. Schools must provide adequate resources for learning because they have an adequate knowledge, background, and pedagogical skills to help students learn.

The absence of a high priority for learning, appropriate time for skilled teachers to help students learn, equipment essential to facilitate learning, administrative support, curriculum evaluation mechanisms, and good counseling, results in an environment that can deter minority students from seeking professional careers in science.

Another important variable is the home or parental support. It is clear that this variable is usually beyond the direct influence of schooling. Parents who seek to participate in influencing school decisions, and have the skills and interest to have a positive influence on student education are important partners with the schools. These parents also provide essential role models as examples of responsible participation in educational activities. It is true that more often than not, the best students come from homes that are partners with schools.

Barriers and Responses are Linked as Illustrated In the Matrix

COMMUNITY	Expectations, Role Models, and Support Network	Professions' Respect and Pride	Priority for Learning	Parental Cooperation
INSTITUTIONAL DEVELOPMENT	Expectations, Inclusion with No Exclusions	Clear Goals	Time to Teach, Equipment, Resources, and Administrative Support	Parental Involvement
TEACHER EDUCATION	Accept Students as Individuals	Effective Learning Environment and Personal Competence	Expectations, Evidence to show learning has occurred, and classroom environment	Cooperation in use of Resources
STUDENT ACTION	Personal expectations, Positive attitude, Academic Priority, and Attendance	Accept students as individuals	Expectations, Time to Learn, Counseling, Assistance, and, Non-exclusion	Parental Priority, and supportive home Environments
	STUDENT	TEACHER	SCHOOL	OTHER

BARRIER

ORGANIZATIONAL DEVELOPMENT, STAFF DEVELOPMENT
AND
IMPROVEMENT PROGRAMS

A. Need and Rationale

We have presented arguments for the fact that a substantial number of minority students are lost from the potential pool of science and mathematics students.

The difficulties involved in increasing this pool are frequently due to problems in the organization and operations of a school, the structure of the curriculum, the attitudes of the teachers, and the attitudes of the students. Many studies indicate that schools can be improved to increase student academic achievement.

B. Effective School Programs

The effective school program has been developed to combat the above problems to produce a variety of reforms at the school organizational level in order to improve student learning and achievement. The process involves use of planning teams composed of administrators, teachers, and parents to study the current school program. Recommendations are made for school-wide goals, objectives, procedures, and activities. Implementation plans are developed from the recommendations. Short term and long term goals are established, and needed staff development programs are designed.

While school organization and development procedures are not new, the recent efforts of the late Ron Edmunds, et al., have provided renewed interest and refinement in this approach, which have been particularly successful in elementary schools in urban settings.

Enrollment data indicate that the 125 largest school districts in the United States enroll over 25% of the total number of students in public elementary and secondary schools. Within these same school districts, nearly 40% of the minority students are in public schools. Effective school programs focusing on reading, mathematics, language, and science should be developed in a number of urban elementary and middle schools as model programs. A primary emphasis should be directed towards developing positive attitudes toward science and mathematics, developing awareness of career opportunities related to science and mathematics, and increasing student achievement in science. Short term goals (one to two years) and long term goals (three to eight years) should be established. Evaluation of the programs should be established to monitor the effectiveness of the programs, and to provide guidance for program modification.

It is recommended that approximately eight effective school programs be developed as model programs. In addition, we recommend establishing four effective school programs in elementary or middle schools in non-urban areas. These sites can provide models for developing programs in these areas. As these schools demonstrate success, additional funds should be made available to establish additional programs in other urban or non-urban settings.

C. Magnet or Special Schools for Able Students

The Bronx High School of Science and other special schools have established outstanding records for providing students with a rich academic climate that has resulted in exceptional student performance and many opportunities for their graduates. Schools with similar purposes have been established in North Carolina, Dallas, Texas, and other locations. In addition, many school districts have established magnet schools where students with a strong interest in science and/or mathematics and demonstrated achievement in these areas can pursue studies with outstanding teachers, excellent facilities, and an able and highly motivated peer group.

We recommend establishing a minimum of three such high schools for minority students. Experience of previous specialized schools should be used in the design of these school programs. Cooperative agreements between the schools, institutions of higher education, and industry should be established. Evaluation should be conducted to document the impact of the programs on the students and to provide information for future program modifications. At least one high school should be placed in close proximity to an institution of higher education with a strong research program in the sciences, and with a major focus on minority students.

D. Alternative Programs for Able Students

In many areas where institutions of higher education and industrial firms are located, many opportunities exist for unique secondary school programs in science and mathematics education. Teachers may be hired from universities and industries (or be provided by them); students may be allowed to use university or industrial research laboratories; advanced placement or second year courses may be developed on a cooperative basis; and students may be involved in research projects with university faculty or industrial personnel. Many other innovative program modifications are possible in such settings. Successful examples of such cooperation can be identified in several urban areas including New York City and Cleveland, Ohio.

We recommend that NSF provide funds for developing, implementing, and evaluating such programs for minority students at a minimum of three sites. As these programs demonstrate their success, funds should be provided to develop, implement, and evaluate programs at additional sites.

E. Historically Black Colleges and Universities (HBCUs)

Important elements in increasing the pool of pre-college minority students with interest and abilities in science are, (1) having minority college and university faculty work with pre-college minority students, (2) providing and maintaining adequate facilities at HBCUs for research, (3) providing role models with a work environment that will encourage students to prepare for science/mathematics/technology positions at HBCUs, as well as at other higher education institutions, and (4) strengthening the research talent and productivity in science, mathematics, and education at HBCUs.

We recommend that HBCUs evaluate their current program, faculty loads, faculty needs, and equipment needs related to science, mathematics, and technical education. Short-term and long-term priorities should be established. Priority programs should receive focused attention, funding should be obtained, and cooperative program arrangements should be established to nurture the program and faculty related to these priority programs. Funding for institution building and staff development should be explored with federal and state governments, private foundations, business, and industry. Cooperative program arrangements should be explored with other colleges and universities, businesses and industry, and federal laboratories and education centers.

Leadership development and networking are crucial elements in the development, spread, and maintenance of programs. For long-term development of minority education, HBCUs should explore with the National Institute of Education the funding of a national center for minority education. Such a center could provide focused attention on minority educational needs; provide a mechanism for assisting minority institutions; develop and maintain a communication network; provide an additional bridge between pre-college and post-secondary educational institutions; provide a mechanism for communicating minority needs to the federal government; and for communicating opportunities to interested individuals or groups.

We also recommend that a Center for Science Education Research and Development be established at a HBCU in which there is associated an active scientific research center; in addition to a Pre-College Center for Excellence in mathematics, science and technology. The science educators at the Center would be involved in curriculum development activities, and would have access to scientists who could serve as technical experts for materials development. The Center would also serve as a type of national center for the dissemination of information, materials and research findings to HBCUs and other institutions involved in pre-college science education.

PROGRAMMATIC THRUST

A. Rationale

At each level of the educational experience, the student population encompasses a wide range of maturity and developmental levels. Especially at the middle and senior high school levels. To allow for individual, as well as group development, a conceptual framework including awareness, exploration, and application experience must be the components of intervention programs The minority student population presents an additional challenge in that often the range of student performance is heavily skewed toward the lower levels of skill development. However, this performance level cannot necessarily be equated with lower aptitude for many of the reasons noted in the introductory section of this component. The intervention programs designed to increase the pool of minorities in science and technology must be broad in their approaches, but with specificity and innovation to reach desired goals. Examples of such programs are the following:

1. Nature Study Centers

This program may be implemented at a specific site or be incorporated into the school site. It is designed to address the problem of student expectations and self concept through in-depth study of a natural environment. Awareness, exploration, and independent study activities are provided for classes, small groups, and individuals. Minority institution support would be given through development, maintenance, and staffing of the center.

2. The Curriculum Science Center Within a School Building

This program is to reduce anxiety toward science and mathematics, to provide exposure to appropriate curriculum, and experience with instrumentation. The program utilizes curriculum materials developed for the targeted population. Curriculum programs designed to strengthen basic and integrated science process skills are taught to determine the effectiveness of the materials and teaching strategies employed for average to high ability students. Analysis of the results of pilot programs would be used to modify existing curriculum materials. Minority institution involvement would include assistance in the development of a research design and provision of consultant services to the science staff at a high school near its location.

3. Student/Teacher Research Program

A teacher initiated project for year-long study is designed to promote student interest, improve attitudes toward science, and develop skills needed to process collected data. An environmental study of the school community, an in-depth study of an organism, and student/teacher science projects are examples of topics which could be used. Minority institution involvement would include assistance in the design and evaluation of the research projects.

4. Utilization of Community Science/Technology Resources Through a Continuing Field Trip Program

A comprehensive visitation program to a variety of science-related community resources over a period of two or three years would be initiated in order to raise student expectations, exposure to career options, and direct experiences with role models. Minority institution involvement would include assistance in the development of procedures for evaluating the impact of the program on student attitudes.

5. Recommendations

1. On an annual basis, each minority institution would become involved with approximately 3 - 4 pre-college institutions in cooperative development of proposals. NSF Programs for Pre-college Science and Mathematics Education serve as examples. High priority should be given to those programs which focus on research in teaching/learning and activities which provide incentives for pre-college teachers.
2. Establish viable partnerships with pre-college science and mathematics teachers in schools with high minority student enrollments through service on Curriculum Advisory Committees and a minimum of two invitations per year to attend a meeting on the college campus.

B. Teacher Education

Excellence in education begins in the classroom. The key to achieving academic excellence is the teacher. Without effective teachers, all other efforts to assist the nation in maintaining its position as a world leader in science and technology will not be successful. Currently, too few adacemically talented students are attracted to the general teaching profession. When the teachers from all fields -- elementary, middle, and high school -- are considered, too many come from the lower twenty-five percent (25%) of our high school and college student populations. Though the profession is overpopulated, the excess tends to be in physical education, social science, elementary education, and health education. At the same time, data based on relative demands indicate considerable teacher shortages in mathematics, physics, chemistry, biology, earth science and computer/data processing. To amplify the point, consider that 50 percent of newly employed science and mathematics teachers do not have basic qualifications to teach their assigned subjects. More than 67 percent of the schools that offer instruction in physics do so with unqualified teachers.

Teachers are a critical factor in increasing the pool of minority students who have access to science and technology careers. And while these teachers need strengthening, three questions help define the programmatic thrust:

-- Who requires assistance?

-- What kinds of assistance are needed?

-- What delivery system will be most helpful?

To describe the pool of teachers who need assistance is to indicate at least three diverse groups:

1. Prospects who have the potential to become teachers, e.g., high school students, undergraduate students with science or mathematics majors, and college graduates with scientific or technical training who have an interest in teaching.
2. Pre-service teachers who have made a commitment to teaching, but as yet have not entered the profession.
3. In-service teachers who are actively teaching either in the field or assigned out-of-field.

Therefore, we recommend that the first step in any thrust to strengthen teachers begin with a clear description of who is to be assisted. There are five categories of assistance for teachers which include; 1) knowledge of the content of their teaching field; 2) application of that knowledge to daily life; 3) skills in planning instruction; 4) skills in presentation, instruction, or working with students; and 5) commitment to teaching as a career.

A variety of delivery systems exists which can be useful in helping specific groups of teachers gain expertise in the five areas. Varying in both length and location, they may range from school courses to full-year leaves. They may be conducted on site in a school building or in regional centers or in college or university settings.

C. Recommendations

Teacher training programs that promote excellence and high achievement have similar characteristics. These characteristics should be identified, collected, and disseminated for broad based use in producing model teacher training programs in science and mathematics. Examples of widely accepted characteristics are the following:

1. Identification, recruitment, and selection of candidates with moderate to high academic achievement records. Adequate funding for scholarships and support services.
2. Provisions for a strong liberal arts background.
3. Provisions for candidates to receive a full major in the content area.
4. Liberal arts and academic departments with major role in teacher training.
5. Professional education that incorporates the latest findings from the behavioral and social sciences, and whose placement in the curriculum matches probable needs.
6. Early and consistent in-school involvement in a coherent and progressive pattern with adequate and consistent supervision.
7. The development of articulated five-year undergraduate-graduate programs would provide for all of the above plus provisions for:
    - Scientific research experiences with industry, national laboratories, and research scientists at colleges and universities,
    - Research experiences in science and mathematics education with researchers at colleges and universities and teacher centers,
    - Co-ops in public schools as aids/paraprofessionals and with business and industry.

8. Establishment of a Teacher Resource Center devoted to enhancing learning of minorities.

At such a Center, research science findings can be translated into instructional procedures designed to fit the learning needs of minorities. This Center could provide the physical location and the salary to permit collaborative efforts of teachers and scientists. It could also facilitate teacher renewal through short courses and summer institutes in addition to longer term involvement.

9. Enhancement of Teaching as a Career

In addition to enhanced salaries in areas of critical needs (science and mathematics), local recognition for teachers, respect from the community, and support from school administrators for a professional teaching environment are essential. The opportunity for collaborative research and development efforts could be linked with equally strong continuing education renewal opportunities which have supervision and feedback components.

10. Credentialling of Teachers Must be Strengthened

Responsibility for establishing credentials for teaching resides in state departments of education. In each of these 50 locations, there must be increased effort for strengthening the minimum standards which must be met for a teaching certificate. Such standards must include a working content knowledge base, especially at the elementary and middle level. We propose that all teaching credentials be subject specific, beginning with Grade Four. We also propose that all categories of "emergency certification" be abolished. If no certified teacher is available, then no class should be taught. The relationship between minority student performance on state certification tests and their college program needs to be examined. While minorities tend to perform poorly on these tests, this may be the result of a bias of the test or not having the opportunity to acquire and practice test-taking skills.

PARENTAL PROGRAMS

A. Rationale

The educational level of parents is an important factor in the determination of career goals for minority students. When Black students have at least one parent with some college training, the frequency of choosing a quantitative major is equal to the frequency of white students choosing a quantitative major. The effect of parental education manifests itself primarily through high school performance and post-secondary education choices. Since many minority students come from families in which neither parent is college educated, it is necessary to provide educational experiences for parents that will affect students' career plans. These educational programs must be designed in such a manner as to increase parental understanding of the educational process and how they can influence that process.

B. Recommendations

Some of the activities that can be instituted to increase parent involvement are listed below:

1. Student/parent career days at local churches and community centers sponsored by minority civic organizations.
2. Student/parent science fun nights sponsored by local HBCUs.
3. Meet the Counselors/Teachers/Administrators Night sponsored by civic organizations and held at churches or community centers.
4. Town meeting format. Commitment must come from parents.
5. Student/Parent College Day held by science/science education departments at HBCUs to expose students and parents to academic programs.

PUBLIC INFORMATION PROGRAMS

A. Rationale

Scientific literacy is important to all individuals who must function effectively in a technically complex society. However, fewer than 40% of the nation's high school graduates have taken more than two years of high school science (fewer than 30% for minority students). If these individuals are to develop a rudimentary understanding of scientific concepts and principles relevant to rapidly advancing technologies, public information programs must be instituted in a variety of settings.

Not only are public information programs necessary for improving the scientific literacy of the general adult population, they are also useful for providing supplementary science activities and information to elementary, middle school, and high school students. The learning activities available to the minority community via public information programs are important in increasing minority student interest in quantitative careers and stimulating achievement in science.

B. Programs

The following programs should be an integral part of the public information program network:

1. Science and technology museums, nature centers, or planetaria that emphasize minority contributions to science and technology.
2. Traveling science exhibits that are transferred from school or other community locations.
3. Regional community education centers that feature demonstrations of scientific materials and principles.
4. Community programs on science and technology issues that may be of special interest to minority and/or urban residents.

5. Television program similar to 3-2-1 contact or 30 second commercial spots that illustrate a scientific principle.

6. A cartoon series which emphasizes science and/or science careers.

7. Science career fairs sponsored by professional organizations to be held at churches, community centers, or wherever students can be expected to congregate. These fairs could be co-sponsored by HBCUs, industry, and other organizations.

C. Recommendations

1. Establish three (3) regional Science Museums whose thematic emphasis is Minority Scientists' Contributions to Science and Technology -- from Ancient Egypt to the present (i.e., CIBA-GEIGY Poster Series).

2. Establish a coordinator of community science programs at selected HBCUs to be responsible for the following activities:

   a. Regional science activity centers

   b. Development of 30 second radio spots on careers in science/scientific principles

   c. Coordinate science fairs, career nights, and college nights

   d. Coordinate a speaker's bureau to provide speakers for events

   e. Dissemination of audio-visual aid materials.

3. Provide funding for the production of motivational television programs by the Science and Telecommunications departments at HBCUs.

4. Establishment of Science Careers Information Networks (SCINET) between institutions involved in public information programs to transfer information between centers and to the public on careers and opportunities in mathematics, science, and technology for pre-college students. The SCINET could be coordinated by the Community Science Program Center of HBCUs.

SCIENCE ACHIEVEMENT PROGRAM

In addition to those efforts directed at institutions and curricula, programs that provide specific activities for students can contribute greatly to pool-building. The literature is replete with data indicating that ethnic students specifically (and all students in general) do not have equal and sufficient access to career awareness, academic enrichment, motivational, and other resources.

Several programs across the country have had a decade of experience in providing such programming for ethnic students. In general, these programs have been successful in producing academically qualified students who could pursue mathematics and science-based majors at the university level. Some programs have focused on teacher training initiatives, others on academic support, and still others on motivational opportunities.

Our analysis has identified the most effective elements and components of these various programs and unified them into a coordinated master program, known as the Science Achievement Program (SAP). This program would concentrate its efforts at the sixth through twelfth grade levels. Its goals would be to increase the number of ethnic and other students who graduate from high school with sufficient academic preparation in mathematics, science, and English to be eligible to pursue a mathematics or science-based major at the university level.

The program can be administered on a consortial basis, operating through an administrative center, or administration could be undertaken by individual campuses.

Each program would operate with 30 - 50 students at ten area high schools (300-500) at at average cost of $100,000 per center. The program would target college-prep and "mid-track" students and ensure that they satisfactorily complete the four years of English, three years of mathematics, and three years of science.

Characteristics of an Effective Student Enrichment Model: SAP

Structure

1. Clearly delineated goals, objectives, population.
2. Effective dates and evaluation mechanisms.
3. A strong interactive network involving schools, family, industry, community, and government representatives (typically through a board).
4. An adequate fiscal base.
5. Dissemination of results.

Programmatic

1. Utilize school teachers, counselors, faculty as intervention agents.
2. Provide continuous, almost daily activities for participants.
3. Offer academic enrichment programs, e.g.
    - a. Special daily mathematics/science/English courses
    - b. Saturday academics
    - c. Ethnic student honor courses
    - d. Summer enrichment programs

4. Offer academic support programming, e.g.
    a. Tutoring
    b. Repetitions
    c. Remedial sessions
    d. Study centers, study groups
5. Build a sense of community for participants, e.g.
    a. Promoting student organizations
    b. Providing common study areas
    c. Providing clustered registration for courses
6. Provide motivational/career awareness activities, e.g.
    a. Field trips
    b. Guest lectures
    c. Academic competitions
7. Involve family unit and industry

    FAMILY:

    - Parental activities
    - Booster clubs, support clubs
    - Special orientations

    BUSINESS COMMUNITY:

    - Field Trips
    - Mentors
    - Summer employment opportunities
    - Fiscal Support
    - Executive Loan Programs

8. Foster academic achievement, e.g.
    a. Scholarship Incentives
    b. Achievement Awards
    c. Academic/design competitions
9. Enhance curricular offerings, e.g.
    a. Examining course content
    b. Expanding basic offerings of necessary science and mathematics courses
10. Providing teacher education opportunities
    a. Summer institutes for teacher
    b. Underwriting teacher-initiated relevant research and activities
    c. Periodic thematic in-service training opportunities.

The national experience of these components and activities indicates that a Science Achievement Program can double the college-going rate of ethnic high school students, and double the number of ethnic students who declare a mathematics-based college major (to 66% from a national base of 30%).

SCIENCE EDUCATION RESEARCH AND DEVELOPMENT

The improvement of science education for minorities is substantially dependent upon the development of a research and evaluation agenda that will provide direction for improving instruction and learning. Several areas of research are recommended to provide better understanding of how minority students learn, the variables related to their learning, and improving programs in which they enroll.

1. Research Related to Academically Successful Minority Students.

Research is needed to gain more knowledge on successful minority students and variables related to their success. This information will provide a better basis for the design of educational programs and help establish priorities for allocating funds for program development and modification.

2. Research Related to Effective Teachers of Minority Students.

More knowledge is needed on procedures and practices used by teachers who have had outstanding success in teaching minority students. The research should identify the particular type of student outcomes (cognitive, psycho-motor, affective), the particular student minority group, and the procedures and practices used by the teachers. This information will be of use to teacher education institutions for pre-service programs and also for schools and organizations concerned with in-service education.

3. Development and Research Related to Variables that Account for the Highest Amount of Variance Related to Minority Student Learning.

A substantial amount of correlational data has been obtained linking many variables to student learning. These data suggest that many recent and current experimental studies in science education are being done on variables that explain a relatively small amount of the variance.

We recommend experimental studies that explore interventions (variables) that account for a substantial amount of the explained variance. Such studies include (1) improving achievement in reading and mathematics, (2) more frequent use and feedback of evaluation data, (3) higher teacher expectation, (4) specific instruction and feedback related to the learning outcome desired, and others. The meta-analysis studies coordinated by Dr. Ronald Anderson (University of Colorado) and others provide many suggestions for additional variables and interventions to consider. Cooperative research that considers a number of these variables in a coordinated way is preferable to isolated studies that cannot be generated.

4. Research related to science attitudes and interests of minority students.

Positive attitudes and positive interests in science are associated with students who decide to continue taking science and mathematics at the secondary school level. In addition, achievement in science has been found to have a generally positive (but low) correlation with student attitudes and interests.

If more minority students are to be encouraged to continue in science and mathematics, then programs that are more effective in developing positive interests and attitudes need to be identified or developed.

We recommend two lines of research. First, assessment should be made of existing programs that are believed to be effective models for developing student attitudes and interests. This research should include (a) postdoctoral studies to identify programs, and (b) pre and post-testing to determine program effects. Secondly, experimental programs should be developed (or existing pro grams modified) to achieve more positive student attitudes and interests. These programs should be evaluated for their effectiveness.

Research should be developed to assess student attitudes and interests at various educational levels and the effectiveness of intervention techniques at different educational levels.

5. Development and Research Related to the Impact of Class Size on Educational Outcomes of Minority Students.

Many current efforts for improvement of learning in elementary schools are compensatory in nature (after learning deficiencies have developed), treat symptoms rather than problems, appear to be more costly than program modifications to correct problems, and do not provide a "success" model.

We recommend developing pilot elementary school mathematics and science programs with classes containing fewer than 20 students designed to

a. increase student achievement

b. provide student success, and

c. develop more positive attitudes and interests toward science and mathematics study and careers. Instruction should be goal centered and provided by specialists in science and mathematics education. The results should be evaluated and instructional efforts modified to improve instruction. Control classes should be evaluated and compared to determine the costs and usefulness of reduced class sizes.

6. Development and Research Related to the Impact of Family/Home Variables on Educational Outcomes of Minority Students.

Several national studies, including the National Assessment of Educational Progress (NAEP), have collected information on family variables related to learning of minority students. We recommend the design of programs to work with parents/guardians of students with (a) negative correlates, and (b) positive correlates to determine the effectiveness of programs for modifying negative correlates and capitalizing on positive correlates.

7. Research on the Relationship of Teaching Styles and Learning Styles of Minority Students.

We recommend developing a state-of-the-art paper related to these topics on science and mathematics education, and convening a conference to identify priority areas of needed research. The paper and recommendations of the conference should be broadly disseminated for reactions from various groups.

We recommend that research be conducted to study these relationships, and the potential usefulness of these procedures for elementary and secondary schools. Efforts should be made to obtain funds for the conference and the research from private foundations, NSF, and NIE.

8. Research Evaluation and Dissemination of Student Programs Related to Minority Students.

A large number of special programs have been developed to encourage minority students to pursue science and mathematics careers. A review of the literature indicates very little research has been done on these programs; hence, little is really known about the effectiveness (or lack of effectiveness) of most of these programs.

We recommend two lines of research related to this area:

(a) funding evaluation of a selected number of programs that are felt to be effective, and

(b) providing resources for further research for selected programs that have already been evaluated and can demonstrate a positive impact.

We also recommend that programs that demonstrate a positive impact be considered for funding by the National Diffusion Network of the Department of Education.

9. Research and Evaluation Related to Public Information Programs for Minority Students and Adults

In another part of this document, we have strongly recommended the establishment of public information programs for minority students and adults. Relatively little information has been documented and published on the effectiveness of information outreach to minority populations and of various types of information.

We recommend that (1) programs that are established be evaluated, and (2) marketing research techniques be used to identify information dissemination techniques that will be effective for various samples of the population.

OVERALL RECOMMENDATIONS

1. Establish R & D Centers to test and evaluate teaching and learning with respect to minority students to be associated with one or more minority college/university.

   . Effective school development (school improvement projects).

   . Informal science/technology out of school educational programs

   . Teacher renewal activities

   . Studies related to science, mathematics, and technology education

   - Cognitive studies

   - Factors influencing interest/achievement in science and mathematics

   - Studies relating to the effectiveness of intervention programs for minority students

   - Policy related to educational practices -- credentialling

2. Institutional/staff development of HBCUs in order to support R & D Center.

3. Establishment of magnets and other special schools.

4. Establishment of Informal and Public Information Educational Programs

   - Science/Technology Museum - Theme Focus on Minority Contributions

   - Traveling Science Exhibits - Minority Contributions to Science and Technology

   - Parental Programs

5. Establishment of Centers for Excellence in Pre-College Science, Mathematics, and Technology Education

   - Teacher Centers

   - Student Programs

   - Counselor Programs

   - Resource Development

THE COOPERATIVE PROGRAM COMPONENT

Plan to Expand and Establish Collaborative Research Programs
between
Universities, Industry, and National Laboratories

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SUMMARY

Minority universities, in collaboration with other academic organizations, industries, or national/federal laboratories, represent an effective vehicle for developing the universities' scientific and engineering programs, as well as influencing the further development of the collaborative partner.

Organizational interfacial relationships include:

1. University-to-University Connections:
    a) Minority University - Minority University
    b) Minority University - International University
    c) Minority University - Majority University
2. Minority University-to-Industry Connections
3. Minority University-to-National or Federal Laboratory Connections

A viable mechanism to increase the participation of historically Black colleges and universities (HBCUs) in high-tech areas is through joint programs involving research and educational curricula with institutions, organizations, or industries established in these fields. The principal motivators for a minority university to develop a cooperative program are: increasing their scientific capability; improving human resource development; and their increased involvement in the planning and execution of science on a broader base.

Increased scientific capability of HBCUs can result from the accelerated development of their existing research programs through: peer interaction and scientific exchange with senior scientists; access to special facilities; and assistance in building and sharing technical support services.

HBCUs involved in one or more of these programs would derive maximum benefits toward developing various aspects of their research and educational programs. General benefits would include:

1) The opportunity to be involved in mission-oriented research of national importance.
2) Opportunities for faculty improvement.
3) Opportunities for student career training not available in institutions with traditional science programs.
4) Student and faculty access to a wide range of support and research facilities.
5) The accelerated development of research programs.
6) Strengthening the institution's capability and potential for interactions, particularly with industry.
7) A means for community awareness of science and technology.

As with other university cooperative programs, the University-University cooperative program represents a novel, cost effective vehicle for developing specific research programs at HBUs. The specific components of this program could include:

1) Collaborative joint research projects.
2) Staff appointments established at respective institutions, e.g., adjunct faculty, visiting staff scientist.
3) Remote access to computational and scientific facilities.

4) Student training opportunities.
5) Mini-courses and seminars at HBUs.
6) Use of scientific support services, e.g., machine, electronic, and glassblowing shops.

Linkages can be exploited from undergraduate through faculty levels. Resources can be concentrated to develop individual and particular institutional strengths, thus avoiding unnecessary duplication and loss of quality. Among the benefits to be derived are:

1) Increase in quality and quantity of graduates.
2) Expansion of areas of competence in teaching and research.
3) Increase the capability of personnel and facilities to undertake or participate in competitive contract research.

Prototypes and models already exist. Periodic evaluations are proposed as a means of monitoring, and mechanisms and criteria for evaluation are suggested.

INTRODUCTION

Minority universities have not achieved equal status with majority institutions and have therefore not attained their expectations of academic excellence. This has resulted in an insufficient impact on the employment market and in many cases is directly related to the lack of an effective infrastructure in most of these institutions. These problems have been strongly underscored by recent social changes and federal legislation.

It is necessary and timely to devise and incorporate mechanisms whereby the educational expectations of the minority population can be realized in the shortest real time. Additionally, a mechanism which demands re-orientation and more economic use of existing plants seem to be eminently desirable. In this way, the strengths of individual institutions can operate in supportive and promotive modes in a cooperative model.

Minority university-collaborative programs are mechanisms by which the individual institution could significantly improve and strengthen their educational plants and enhance both the quality and quantity of the student graduate.

The sharing of facilities, either by direct or remote use, offers enormous possibilities in the areas of curriculum development and expansion, development of cooperative research, conferencing, and idea generation. In addition, staff and student exchanges will inevitably broaden experientially derived expertise.

UNIVERSITY-TO-UNIVERSITY CONNECTIONS

A. MINORITY UNIVERSITY-TO-MAJORITY UNIVERSITY LINKAGE

The role of majority institutions in the academic and economic development of minority institutions can be of unlimited potential as minority institutions adjust their capabilities to meet the demands of economic and technological changes. In the simpliest terms, a major factor in economics, educational, and technological development is retraining and creating new jobs; retraining of the currently employed and underemployed, and creating new jobs for the unemployed and new graduates from all types of educational and technical programs. Improving the economy greatly depends on higher education's preparation of the future workforce and the upgrading of skills and knowledge of the existing workforce.

Typically and historically, majority institutions of higher learning represent more diversity in responding to the needs of the economy than the historically minority institutions. Enormous opportunities for linkage of minority institutions with majority institutions of higher education exist where there is significant potential for mutual benefit. Because of the majority institution's historical advantage in diversity, a linkage between the minority and majority institutions can contribute significantly to the minority institution's capability in economic and technological development.

Special Advantages

Historically, minority institutions have concentrated on developing curricula in the basic and fundamental areas. However, energy, environmental, technological, and economic concerns of the seventies and early eighties have led to a need for more and broader interdisciplinary curricula fields.

For many reasons, it does not appear economically feasible or practical for minority institutions to independently develop curricula and research programs. There is, however, a need for minority institutions to participate in the delivery of such programs. A viable mechanism is through joint programs involving research and educational curricula with majority institutions established in these fields.

Successful, ongoing linkage programs already exist which serve as models are:

1. The Lawrence Berkeley Laboratory - Jackson State University Cooperative Program;
2. The Atlanta University Center and the Georgia Institute of Technology Cooperative Program; and
3. The North Carolina A & T and the Golden Research Triangle Cooperative Program.

B. MINORITY UNIVERSITY-TO-INTERNATIONAL UNIVERSITY LINKAGE

USICA has recognized the benefits and importance of University-University (U-U) linkages and has a program established for the initiation of such collaboration. This program provides seed funding for the international exchange of scholars. The Fullbright/Lospau International Exchange Program also addresses the needs of some institutions for strengthening their teaching and research faculty.

Methodology of University-University linkages has already been developed both internationally and regionally. For example, the three campuses of the University of the West Indies are linked by satellite to provide delivery of courses, seminars, and other interactions. External and internal assessment of staff and student performance and course viability are already carried out in many institutions. For example, the appointment of external examiners to supervise the examination of higher level (3rd and 4th years) courses.

The Jackson State University-University of the West Indies Linkage (JSU-UWI).

A Memorandum of Understanding (MOU) has been agreed upon between Jackson State University and the University of the West Indies whereby each institution undertakes to cooperate in seeking external funding for the following purposes:

1. Travel, remuneration, and accommodation of exchange and research staff.
2. Scholarship and fellowships for graduate studies.
3. Overhead costs of research projects.
4. Procurement and supply of books, equipment, and other materials on long or short-term loans or as gifts.
5. Other costs arising out of the implementation of the agreement.

The agreement extends to cooperation in the development of research programs and proposals for funding of such programs, and it allows for individual staff and student appointments at institutions encompassed within the terms of the MOU. The final terms of the agreement were determined on the basis of trial staff and student exchange, cooperative research efforts at JSU, visits, and an indepth study and assessment of the resources at each institution. It is expected that seed money for start-up activities will be provided through funding from USICA under its U-U linkage program (Office of Academic Affairs).

In a U-U linkage, the University of West Indies could be a unique partner. Historically, it is molded from and structured after the traditional English university pattern. As such, entrance to science faculties requires four years of high school mathematics, and three or more years of the relevant science subjects, coupled with good language competence. Students whose general competence is somewhat below the required standard can enter the University for a preliminary year for the necessary improvement, and if successful, be fed back into the three year program. There is a very high retention and pass rate. Students who perform in the upper half of the grading profile (honors) are immediately eligible for acceptance into graduate school, not only in the University of the West Indies, but also in British universities. Additionally, these graduates have had an exceptionally high success rate in North American universities (including Canada).

The retention rate of students in the UWI graduate programs, and the return rate from foreign universities have been sufficiently high to provide a large percentage of the university staff. Some departments are completely staffed by such graduates, and indeed sometimes special efforts must be made to internationalize the staff complement. The role model and national group interest functions are therefore quite adequately served. The number of these graduates that now serve in key industrial and political positions further serve to raise the psychological profile.

The major deficiency lies in securing funding for large scale research programs. Graduate programs are primarily financed at the individual level. As a result, UWI has been unable to sustain any significant projects involving team effort where multifaceted research programs could be carried to completion.

Specific Benefits from this Model

1. Domestic Minority Institutions
   - a) Collaboration with well-trained and experienced staff accustomed to meeting international standards of course delivery, curriculum development, and examination procedures.
   - b) Interaction of domestic minority students at the graduate and undergraduate levels with graduates of #1 above.
   - c) Access to unique environments for the study of the sciences; environmental, marine, atmospheric, and natural products; also exposure to different cultural perspectives.
   - d) Access to the experience of Distance Teaching methodologies as a means of effecting University-to-University linkages.
2. External or International Minority Institution
   - a) Participation in team cooperative research projects and the development of such projects.
   - b) Access to advanced technologies.
   - c) Increasing the academic research productivity of the individual faculty members.
   - d) Providing a feeder for graduates into programs at domestic and external institutions.

Programmatic Thrust

The major thrust at UWI is in the area of Environmental Studies -- biological, econological, chemical (including natural products), and atmospheric aspects. Collaboration is possible with existing centers such as the Center for Environmental Studies and Resource Management. Specific areas for attention are:

1. Educational
    - a) The heightening of public awareness involving matters of environmental importance through public lectures, workshops, and short-term training courses.
    - b) Providing training at the undergraduate and post-graduate levels for prospective employment in environmentally sensitive positions.
2. Research
    - a) Undertaking investigations which establish the environmental standards for safeguarding resources, including humans.
        - i) water quality
        - ii) air pollution at the workplace and in the habited vicinity of industries
    - b) Resource econology -- the natural ecology of a resource, e.g., the beach and nearshore.
    - c) Development of viable U-U models.

Projected Outcomes

1. Immediate enlargement of the body of qualified and experienced researchers.
2. Possibility of cross-fertilization of ideas.
3. The extension of the available physical plant and hence, the more cost effective use of each unit.
4. Increasing the pool of graduates.
5. Extending the areas or facets of scientific research that might be investigated.
6. Extending the exposure of researchers at all levels to the technology in the field.
7. Improving the international currency value of the products of the programs.
8. The University of the West Indies serves a group of islands separated by as much as 1,500 miles and its experiences in distance teaching could be of a distinct advantage in developing linkages and effecting delivery.
9. Increased scholarship and career development opportunities for entrants into the science disciplines.

C. RECOMMENDATIONS (FOR IMPLEMENTATION) OF UNIVERSITY-TO-UNIVERSITY LINKAGES

1. The establishment of more University-to-University linkages of three types:

   a) Minority University-to-Minority University

b) Minority University-to-International University

c) Minority University-to-Majority University

2. Models which already exist should be developed to assess their wider applicability. Those in their infancy should be allowed to develop for possible use as models. Further, there should be periodic review of the:

a) Effectiveness of all models with a view to modifying them or extending their applicability.

b) A mechanism for internal and external academic assessment and evaluation on an annual basis should be established, and either use existing models or devise more suitable models with a view to improving accreditation.

3. Evaluation committees to assess all aspects of the linkages and to take part in the reviews in #2.

4. Establishment of a teaching/research fellowship program for minority institutions using selection and administrative methods already used by recognized agencies and organizations, e.g., LASPAU.

D. MECHANISMS (FOR IMPLEMENTATION) OF UNIVERSITY-TO-UNIVERSITY LINKAGES

1. Minority University-to-Minority University

The linkage of minority universities can be best implemented by signing MOU's with stated aims and objectives. Staff exchanges could be used as a means of improving exposure of other faculty and students to the most highly qualified staff. Staff sharing could be instituted without depleting the resources of the donor institution by link-up of the physical plants using teleconferencing facilities to deliver courses, lectures, seminars, etc. (Such a system is already in place between the three campuses of the UWI and some of the territories it serves; some as many as 1,500 miles apart). The availability of advanced technological and electronic aids allows for the speedy and relatively low cost emplacement of such systems. For example, the use of telephone linkages, video tapes, slowscan, telewriters, and modem-linked mini/micro computers facilitates for the delivery of courses, etc. The use of overnight transit facilities for sending and receiving assignments from students could aid in assessment. Staff so relieved of basic teaching duties could participate in small group interactions, e.g., tutorials or supervision of undergraduate or post-graduate research.

2. Minority University-to-International University

The linkage of minority institutions with others in the Caribbean and possibly South America is a possible mechanism for achieving the stated objectives. The USICA has a University-to-University linkage program aimed at providing seed funding for such linkages, and can be used as a vehicle for the establishment of such cooperative arrangements. Staff could be exchanged for the delivery of time specific courses. Students could be attached to external universities for courses which seem necessary for the students' specific needs and which are not offered at his native campus.

3. Minority University-to-Majority University

Linkages of minority institutions with majority institutions are a possible mechanism for realizing specific goals and objectives of the minority institutions. There could be staff appointments, both academic and technical, from the minority to the majority institution for specific periods for study and training. This could aid in the development of faculty and technical staff and their ability to meet the changing needs of their institutions. Majority universities could provide fellowships for academic staff to complete Ph.D. degrees for example, and for technicians to learn skills for the operation and troubleshooting of specialized equipment. Graduates and undergraduates from minority institutions could participate in research programs at majority institutions. Cooperative research programs could be developed between faculties of the two types of institutions.

Experienced staff from majority institutions could be attached to minority institutions for the purpose of establishing certain programs and for participating in joint projects.

E. EVALUATION OF UNIVERSITY-TO-UNIVERSITY LINKAGES

1. Mechanisms for Evaluation:
    a) Planning and evaluation committees are to be established and meet quarterly for interaction and preparation of progress reports.
    b) These quarterly reports will form the basis for annual reports and compilation of statistics.
    c) Annual written evaluations will guide the planning and costs estimates for the ensuing year.

d) At the 3-5 year point, a complete review will be made of the sub-units and statistics of the projects for assessment of success.

e) Besides assessment for funding purposes, there should be independent educational assessment of the project to be tied into the accreditation review.

2. Criteria for Evaluation:

a) Rate of acceleration of enrollment of undergraduates.

b) Rate of acceleration of retention.

c) Improvement of pass rate and quality.

d) Scope of program addressed (education/research).

e) Measurable benefits in terms of workshops, publications, reports, or production of otherwise useful materials.

MINORITY UNIVERSITY-TO-INDUSTRY CONNECTIONS

Rationale

University-Industry research connections represent opportunities to maximally utilize limited technically trained manpower and limited research funding resources. A very wide spectrum of University-Industry relationships (documented in the 1982 National Science Board annual report) are successfully in place nationally. Typically, a participating major university will interact with an industry in a number of different modes. The important opportunity for minority universities is to extend and expand their relationship with industry beyond general research support in the form of industrial philanthropy. Such enhanced participation in a University-Industry relationship must take full cognizance of the differing motivation factors obtained for each in such relationships, and must be based on a careful local analysis of both the opportunities and the limitations/problematics that will occur in actual implementation. Significant opportunities are identifiable for minority universities in the engineering and computer science disciplines and in establishing relationships with high technology minority businesses. Whereas the burden of initiating University-Industry connections must, in many cases, be borne by the University, state and federal agencies can have a significant role in fostering them through the provision of seed monies for planning, tax incentives to industry for participation, and through setting generally supporting policy.

Industry HBCU Academic/Research Collaboration

Historically, industry support for HBCUs has been in the form of gifts, grants, and minimally enforced general research support. At the same time, its support for majority universities has a stronger element of interaction and involvement as illustrated in the following table of majority support classes:

- Cooperative research and cooperative technical planning -- 60%
- Technology transfer -- 14%
- Transfer of information/knowledge, e.g., consultants, adjunct faculty -- 13%
- Gifts, grants and general research support only -- 13%

This discrepancy in the form of existing support and the parallel discrepancy in the amount of dollar support to minority institutions point up a major deficiency in HBCU-industry connections. If HBCUs are to receive support appropriate to a goal of strong Academic/Research programs in science, they must be more intimately involved in a participatory manner with industrial staff. The following types of programs could be initiated between HBCUs and industry to provide a mechanism for such participation:

1. The develoment of industrial affiliated programs at HBCUs in scientific areas where several companies financially support the development of a specific scientific sub-discipline (e.g., robotics, artificial intelligence, thermal sciences, microelectronics). These companies then have priority access to students and research results.
2. The development of support for knowledge/information transfer programs. Industry would supply adjunct faculty in science, mathematics or computer science, and provide consultants who can support research programs and give short courses, seminars, or lectures.

3. The development of collaborative research programs derived from cooperative technical planning.

4. The establishment of research and development institutes/centers.

These programs are based on the view that technology-based economic development is essential to the nation's future and that the R & D and technology gap between many of the states where HBCUs exist and other parts of the country is very large and not being closed. They are also focused on building upon the nucleus of research efforts and potential currently existing in HBCUs and also upon integrating important support services for technology transfer, application, commercialization, and economic development.

MINORITY UNIVERSITY-TO-NATIONAL LABORATORY CONNECTIONS

A. PRESENTATION AND PERSPECTIVES

The national/federal laboratories represent a valuable resource that must be integrated into the problem of minority underrepresentation in scientific and engineering fields. These laboratories offer established research programs, experienced research staff, and facilities not generally found at universities or colleges. They also have well-established relationships with funding agency program managers. In this effort to link minority institutions to laboratory programs, it is crucial that the collaborations be based on peer relationships. In this regard, it is essential that minority institutions that are considered have in place a sound academic program at the graduate level, and established and productive research programs. It is essential that the stated goals of the collaboration are well defined and achievable and that they are documented by a memorandum of understanding and intent. Management support must be explicit. An example of such a synergistic relationship is described in a memorandum of Understanding (MOU) between the University of California Lawrence Berkeley Laboratory (LBL), and Jackson State University (JSU). (A description of this cooperative agreement is presented as Appendix A).

1. Other Examples of University - Laboratory Models

Following the successful implementation of the LBL-JSU agreement of cooperation, several other similar agreements between minority colleges and national laboratories were created and are in varying degrees of development: Lawrence Livermore Laboratory and Howard University; Oak Ridge National Laboratory and Atlanta University; and more recently, Sandia National Laboratories and Jackson State University. The latter is interesting because it validates the duplicability of the existing LBL-JSU interaction. Sandia has a different primary mission (defense) than LBL (basic research) and has a different administration and management structure dictated by their contractor (AT & T Technologies manages Sandia, and the University of California manages LBL). Despite these quite different operating environments, Sandia has been able to take advantage of LBL's model and in less than six months has initiated seven programs with JSU involving joint research projects, staff exchanges, and special facility access.

Another lesson in establishing these ties, even with the advantage of prior LBL experience, is that the Sandia-JSU progress has required a dozen exchange visits, involving over twenty people. The creation of these cooperative programs takes time and committed effort of the professional involved.

2. Extention of the Model - Academic Development

The LBL-JSU model discussed above can be extended to assist minority colleges and universities in establishing undergraduate and graduate degree programs in the sciences. Many of these minority schools developed degree programs with limited offering of general science courses. Degrees in pure scientific disciplines generally are not offered. Thus, these programs do not offer minority students a sound background to pursue science careers in education, industry, or in fact, the background required to meet modern technological requirements for preparing high school students for science careers.

In order to upgrade such programs so they may offer degrees in scientific disciplines, it is proposed that national/federal laboratories and HBCUs with graduate programs in science jointly established collaborative programs.

An example of such a tri-institution collaborative program has developed between JSU (a historically Black University); the Ana G. Mendez Educational Foundation in Puerto Rico (a Hispanic University system); and the University of California - Lawrence Berkeley Laboratory. The program began in 1983, and is documented by a Memorandum of Understanding and Intent.

3. Possible Implications for the "Americas"

An extension of the concepts described above could become an educational program for the implementation of the Administration's Carribean Basin Initiative. Universities in the Caribbean region could be linked with U.S. educational institutions and national laboratories in a synergistic relationship. The educational, sociological, and political implications are far-reaching and highly significant. Such relationships are not new to national laboratories. Jackson State University has already implemented this model in Barbados with the Cave Hill campus of the University of the West Indies, and the University of California Lawrence Berkeley Laboratory staff has informally supported the program.

4. University-Laboratory Perspectives

Cooperative programs between national laboratories and universities will have longetivity and support if the needs that motivated such collaborations are met. In setting up such collaboration, it is important to understand and address the motivation of the participants. These motivations need not be the same for all participants and, generally, they are not. But recognizing them as an important element in steering the program development provides a positive and productive relationship. We therefore discuss below the perspectives of universities and national laboratories for such collaborations.

5. University Perspective

The principal motivators for a minority university to develop a collaborative program with a national laboratory are: increasing scientific capability; improving human resource development; and their increased involvement in the planning and execution of science on a national scale. Increased scientific capability for the HBU can result from the accelerated development of existing research programs through peer interaction and scientific exchange with senior scientists at the national laboratories. Such interaction also provides access to special facilities which only the national laboratories have assistance in building and sharing (or provision of) technical support services.

Increased involvement in the planning and execution of science may well be the single most important motivation resulting in more mission-oriented research projects. This motivation could result from exposure to developed research programs at the laboratories and the laboratories' closer interaction with agency program managers in Washington. This increases the chances for funding and can result in research projects that respond to immediate and newly-envisioned needs at an early stage. The national laboratory partner can add credibility to proposals when viewed by the federal agency, especially if the minority institution is proposing a new effort as part of an attempt to develop new scientific programs.

6. National Laboratory Perspective

The national laboratories view such collaborations from quite a different perspective. They will respond to the general desire to address their own human resource needs, show responsible leadership in promoting scientific exchange, technology, and transfer special facility access to minority institutions. However, they will also see specific benefits for their own mission requirements by involving a broader set of scientific talent in dealing with the technical challenge of their laboratory's mission and, in some cases, they may be able to develop new programs themselves because of access to the HBUs talent, skills, and ideas. These collaborations, although adding administrative responsibilities, may significantly increase the cost effectiveness of research execution through access to appropriate science centers that reside in many of the minority institutions.

B. RECOMMENDATIONS

It is recommended that a limited number of collaborative relationships be established between minority universities and the national/federal laboratories. Furthermore, that four collaborative programs be supported from federal resources. A national laboratory should be selected as a "lead laboratory," to administer the minority university national/federal laboratory program. The funding federal agency should be appropriated for the program through this national laboratory.

The criteria for participation by minority institutions are:

1. A graduate degree program in relevant scientific disciplines.
2. An established and documented research program in relevant areas of science.
3. A support infrastructure that would encourage a university-national/federal laboratory collaboration in scientific research.
4. Visible management support.

Collaborative relationships must be documented in a Memorandum of Understanding and Intent or a similar document. The document should contain explicitly or implicitly:

1. A statement of intent and objectives.
2. Delineation of responsibilities and authorities.

3. Well-defined and achievable goals. (At the outset, it is important that the focus of the program be only as broad as can be addressed comfortably. Near term goals should be conservative. It is very desirable that progress be demonstrated early in the development of the program).
4. A provision for periodic assessment and evaluation. (A review and advisory comittee is recommended).
5. Provision for redirection or broadening of objectives as the relationships mature.
6. A commitment on behalf of all participants to the provision of resources; human, financial, equipment, etc.
7. Provision for resolution of issues (all problems will not have comfortable solutions).

C. RESPONSIBILITIES

1. University and National Laboratory

The primary role of the institution, either minority university or laboratory, is to provide the support and framework that will encourage relationships that will grow and mature. A secondary, but very important responsibility of the institution is to interface with funding sources; federal, state, private, etc.

2. Federal Agencies

The federal government must provide the ambiance and resources required to support minority university-laboratory collaborations at a viable level. The number of such collaborations, of course, will depend on availability of funding and the resources of the institutions. It is very important, however, that a focused and concentrated approach be adopted rather than a "spread the wealth" approach.

Specific Responsibilities

a) Seek legislative authority to fund program development where such authorities do not exist.

b) Encourage program managers to fund collaborative research programs.

c) Assist minority university laboratory collaborations in the preparation of field task proposals, and in moving proposals through the budget cycle.

d) Seek funding for program development, educational, and research programs until an established program is in place.

COST ANALYSIS - FIRST YEAR

1. UNIVERSITY-TO-UNIVERSITY MODEL

Development of collaborative research	$160,000
- Travel	
- Housing	
- Per diem Clerical (part time)	
- Administrative (part time)	
- Printing	
- Computer Link-Up	
- Acquisition of Library Holdings	
Establishing scholarships and fellowships for graduates	
- Three (3) students from each institution	$ 90,000
- Tuition (room and board)	
- Travel (stipend)	
- Health Insurance	
Adjunct Faculty Exchange	$100,000
- Appointment -- five (5) faculty	
- Salary differential	
Student Research Internships	$ 60,000
- Six (6) students	
Overhead (30%)	$ 27,600
TOTAL	$437,600

2. UNIVERSITY-TO-LABORATORY MODEL (LBL-JSU Model)

Collaborative Research Program Development and Administration — $300,000 per collaboration

- Review and Advisory Committees
- Professional Staff (Part time)
- Travel Contingency Funding
- Housing
- Administrative and Clerical Staff (Part time)
- Printing and Mailing

Source of funding: Requires use of federal agency contingency funding or line item federal agency funding.

Funding of Research Projects:

- Funded by program managers through the normal review process. Dollar amounts determined by projects receiving funding.

Source of funding: Requires no "new" federal money.

Short Courses, Seminars, Colloquia, Workshops — $ 50,000

- Laboratories will make on-line contribution of scientific staff salary.

Source of funding: Federal agency will fund program.

Student Co-op Program	$ 75,000

- Two semester, eight students per semester.
- Travel
- Stipend
- Housing

Source of funding: National Laboratory funding.

Specialized Equipment and Computer Link-Up

- Computer link-up between minority institutions and national/federal laboratories	$ 25,000
- Specialized equipment, i.e., lasers spectrometers, etc.	$ 75,000
Total	$525,000

3. UNIVERSITY-UNIVERSITY-LABORATORY MODEL (JSU-LBL-ANA G. MENDEZ EDUCATIONAL FOUNDATION MODEL)

- Academic development for undergraduate minority universities	$365,000

NOTE: Appropriate overhead must be added according to the overhead financial policy of the participating institution.

APPENDIX A

LBL-JSU COOPERATIVE AGREEMENT

APPENDIX A: LBJ-JSU COOPERATIVE AGREEMENT

The University of California's Lawrence Berkeley Laboratory had, as early as October, 1978, begun a sustained effort to increase the involvement of scientists and researchers in minority institutions who were capable of contributing to scientific programs which met the U. S. Department of Energy's mission. These efforts culminated in the development of a collaborative program between scientists at Jackson State University and the Lawrence Berkeley Laboratory. A Memorandum of Understanding and Intent formalized the relationship. The product is a successful program of scientific and educational collaboration.